SEX DIFFERENCES IN SPATIAL ABILITY IN CHILDREN: ITS BEARING ON THEORIES ACCOUNTING FOR SEX DIFFERENCES IN SPATIAL ABILITY IN ADULTS

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DECLARATION

I hereby declare that this thesis has been composed by me, and that the work in it is my own.

Signed

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ABSTRACT

This study concerns sex differences in spatial ability in children. Two projects in this area are presented and their results discussed in the context of theories attempting to account for sex differences in spatial ability in adults.

In project one, 70 boys and 70 girls, aged from seven to eleven years, performed a battery of psychometric tests in individual test sessions. The tests had been selected on a two-fold basis. Firstly all had been reported in the literature as showing sex differences in favour of males, and secondly all had been regarded in these studies as measuring spatial ability. In project two, 88 boys and 102 girls, aged 12 to 16 years, performed a similar battery of spatial tests in a group session. In both projects subjects were also given a measure of general intelligence.

Results indicated that many of the tests used measured mainly general intelligence. Sex differences, in favour of males, were only shown for children aged over 14. Girls' scores on the tests used were shown to intercorrelate less highly than boys' scores did. In addition, girls' scores on the spatial tests showed a less consistent increase with age, than boys' scores did. Relevant experience and motivation were shown to be associated with higher spatial scores.

Theories attempting to account for sex differences in spatial ability in adults were reviewed in the context of these results and in the context of similar findings in the literature. It was concluded that to a large extent sex differences in spatial ability are social in origin. However the interactional effect of a possible difference in the hemispheric lateralisation of the sexes was not excluded.

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CHAPTER THREE: THE METHODOLOGY OF THE TWO PROJECTS

CHAPTER FOUR: THE THEORETICAL STATUS OF A 'SPATIAL' FACTOR OR FACTORS

CHAPTER ONE: DOCUMENTED SEX DIFFERENCES IN SPATIAL ABILITY

Introductory Note

Contemporary interest in the topic of sex differences is widespread; the growth of women's movements and the recent passing of legislation to end restrictive practices in employment and public life mirror a growing awareness that women have, in the past, been subject to discrimination. Some commentators (e.g. Greer, 1970) maintain that the under-representation of women in public life and in most of the professions arises from structural causes and reflects their subordination to men both in the public and domestic domains. Others (e.g. Stassinopolous, 1973) argue that this observed imbalance between the sexes in public and professional life is predicated on psychological differences between the sexes.

This public controversy has its counterpart in the more specialised psychological press as well. Within the past five years four major books have been published that deal with the psychology of sex differences and its implications in the social world. (Ounsted and Taylor, 1972, Friedman et al., 1974, Maccoby and Jacklin, 1974 and Lloyd and Archer, 1976.) Each of these seeks to tabulate empirical research on sex difference and to account for observed patterns in these.

But as Block (1976) writes, 'To survey, evaluate and distil the empirical evidence regarding psychological sex differences at a time of intense, polarised debate on the issues of equality of the sexes and changing sex roles is an awesome responsibility' (p. 283). Inevitably as Lloyd notes, 'material presented as scientific evidence is used to buttress opinion and to lend credence to views already held' (Lloyd, 1976, p. 18). Indeed the scientist's own norms and values cannot be excluded from consideration. Thus any review of this 'inchoate field' (Block, p. 285) must itself embrace, probably more by omission than in any other way, the author's own construction of reality (Berger and Luckman, 1971).

As Lloyd has pointed out two major perspectives on sex differences dominate current views. The first which she labels 'biological determinism' seeks to relate most observed sex differences in behaviour to biological bases. The second, the interactionist perspective, commits itself exclusively to neither a social or a biological bias but integrates findings from both sources within a feedback model. Thus, for example, a 'research study based upon an interactionist model would study not only effects of hormone level on behaviour but similarly the effects of behaviour on levels of circulating hormones' (Lloyd, p. 14).

This study deals with sex differences in spatial ability. In this first chapter I will discuss in some detail empirical findings in this area. Then in Chapter 2 I will document the theories that have been postulated to account for these intersex differences. The theories will be viewed from the perspective proposed by Lloyd (above).

Sex Differences in General

In a recent, detailed and cogent review of sex differences in cognition, Fairweather (1976) concludes 'With respect to sex differences in cognition one can only conclude that there are very few ..... Certainly, the incidence of such differences is outnumbered by the qualifications noted in the present review: culture; birth order; family size; sex of experimenter and replicability both between and within studies' (p. 266).

Indeed an inspection of the general area reveals much support for this conclusion for most of the abilities considered. Taking verbal skills as an example contradictions soon appear.

Hutt, (1975 B), in a book devoted to a consideration of sex differences reports 'It is in the area of verbal skills that women come into their own' (p. 94) and enumerates the areas where women show this superiority as 'the executive (her italics) aspects of language-reading, writing, spelling and so on' (p. 95). Yet Thompson (1975) shows in a detailed review that sex differences on reading related tasks are seldom found above the age of ten years. Even below ten years of age, findings are inconsistent, though the majority of findings show girls as superior.

Further in Africa Vernon (1969) and Siann (1970) report boys as performing appreciably better on vocabulary and other attainment tests which depend heavily on language.

Conflicting reports such as these on verbal skills permeate the literature on sex differences. Even where sex differences appear consistent in a number of studies, the direction may shift with experimental manipulation. Piagetian tasks, notably conservation, show this effect. Maccoby and Jacklin (1974, Table 3.11) List 29 studies of conservation; twenty-one show no significant sex differences, six show them in favour of males and two in favour of females. This might be regarded as a small but consistent tendency in favour of boys. However Brekke and Williams (1973) find girls at six years significantly better at conservation of substance noting that the sex of the experimenter may have provided a crucial difference. Fogelman (1970) also shows girls superior at conservation of substance at seven years but he shows an interaction with the experimental conditions: girls only scored significantly better where the task was passive - when manipulation of the plasticine was allowed there was no difference. (Incidentally neither of these two last studies are quoted in Maccoby and Jacklin's table although the latter was done four years before the publication of the book.) Similarly Willemsen (1974) refers to a cumulating number of instances of the influence of specific materials and procedural details in Piagetian tasks on sex and age differences.

Another area where boys are regarded as consistently scoring higher is arithmetic problems. And again this tendency appears to be related to motivational variables. Dwyer (1974) performed a multiple regression study on 385 children in Grades 2, 4, 6, 8, 10 and 12. She related reading and arithmetic scores to biological sex, perception of arithmetic and reading as sex appropriate or not, and individual preference for masculine or feminine sex role and liking of reading and arithmetic. She found that sex differences in reading and arithmetic were more related to children's perception of them as sex appropriate than to any of the other variables listed above.

But it is not only in the cognitive domain that controversy over the empirical data is found. Block (1976) in reviewing Maccoby and Jacklin's monumental summary of sex differences complains of 'slippages' in evaluation of the data. Specifically she notes that in their tabular survey on sex differences in activity level they omit nine studies that are in fact included in their annotated bibliography. She concludes that the 'omission of these nine studies clearly affects importantly the conclusions to be drawn from sex differences in activity level' (p.229). In summary then it is fair to say that in many areas there is little concensus as to either the existence of sex differences or the inferences to be drawn from these differences, where they are seen as being consistent, With respect to spatial ability, however, the picture is quite different. The following comments are I think a fair reflection of agreement in this area: 'Males have been shown to be more proficient in spatial tasks than females' (Hamburg, 1974 in The psychobiology of sex differences, p.388)

'Men excel in spatial ability' (Hutt, 1975 B in Males and Females, p. 92) 'The male superiority in our species in tasks which demand the perception and use of spatial relationships has often been remarked' (Buffery and Gray, 1972 in Sex differences in the development of spatial and linguistic skills, p 123) '... men doing better than women as nearly always occurs with spatial tests' (McFarlane Smith, 1964, in Spatial ability: its educational and social significance, p. 255).

Defining Spatial Ability

It will be seen from the following discussion that indices of spatial ability vary considerably. As Fairweather (1976, p. 249) notes 'it is clear that the term 'spatial' has been used to connote a motley collection of skills'. In Chapter 4 I will attempt to define the term precisely. In this section in order to document the wide variety of studies adduced as showing intersex differences in spatial ability I will define the term operationally as 'that which is measured by tests regarded as spatial', acknowledging the circularity of the definition.

I will report sex differences under three headings (a) tests specifically designed to measure spatial ability (b) tests measuring field independence which are often quoted as measuring spatial ability and (c) tests that were originally designed to measure neither spatial ability nor field independence but that have been quoted as showing intersex differences in spatial ability.

Sex Differences in Spatial Ability in Adults

(a) On the three major standardised spatial tests, i.e. the Guilford-Zimmerman spatial orientation, the Guilford-Zimmerman spatial visualization and the Differential Aptitude space relations test (DAT), men are consistently reported as scoring higher. (Guilford, 1967, Hartlage, 1970). (See Appendix VIII for examples of these tests). Similarly with other tests designed for this purpose - the PMA space relation test (McGlone and Davidson, 1973) and the Identical Blocks test (Stafford, 1961) men score significantly higher than women. (In the last study for example, men scored, mean = 10.2, s.d. = 4.1, women scored, mean = 6.3, s.d. = 3.2, n = 104).

I have only come across two studies that do not show this trend for standardised space tests. In the first case Cohen (1976) performed an extremely small study (n = 12) with men and women aged over sixty on three standardised tests and men scored significantly better on only one. In the second study, McGee (1976) using the mental rotations test with 112 University tests showed that when left-handed subjects were withdrawn from the analysis men failed to score significantly better than women.

(b) Many authorities, notably Sherman, regard tests of field independence as measuring spatial ability and little else. The concept of field independence originates with Witkin and his colleagues (1948, 1962, 1967) and I will discuss its relation to spatial ability in both Chapters 4 and 9. For the moment I will outline the concept and describe the two major tests of it before discussing intersex differences on measures of field independence.

Field independence was defined by Witkin (Witkin et al., 1962) as the ability to separate an item from its context and he has described it as a highly analytical approach to the perception of visual material. However he has also developed an extension of this concept to other levels of psychological functioning, claiming that a tendency towards either a more global (field dependent) or a more articulated (field independent) mode of visual perception is a consistent feature of any individual's manner of dealing with his emotional functioning as well.

Witkin uses two main measures of field independence. In the first, embedded figure tests (EFT) the subject is required to find a particular simple pattern in a larger more complex one with which it shares many of its contours (see pp 565-70 for an example of an embedded figure test).

The second major test of field independence is the rod-and-frame test (RFT). In the original version of the rod-and-frame test the subject is seated in a completely darkened room and required to adjust a luminous rod in a luminous frame to a position he perceives as upright, while the frame remains at its original position of tilt. The closer the rod is adjusted to the tilt of the frame and the further away from true vertical, the more field dependent the response. Latterly portable versions of the test have been developed (Oltman, 1968).

Intersex differences on these two tests (men being more field independent than women) are often cited in reviews of sex differences in spatial ability (see e.g. both Maccoby and Jacklin and Buffery and Gray). However the results are not always consistent with men being more field independent. On RFT for example the following studies find no significant sex differences - Sherman (1974), Kinsolving and Bone (1971) and Oltman (1968). On EFT the following studies failed to show men as being more field independent, Sherman (1974), Hyde et al., (1975), Strauss (1969) and Mayo and Bell (1972).

(c) Reviews of the literature on spatial sex differences often contain references to tasks that are seen as having spatial components though not originally designed as spatial tests. As will be seen later this is more common in reviews on sex differences in children. However in adults among tasks cited are mazes, block design on the Wechsler adult scale (WAIS), rotary pursuit tasks, and having a 'good sense of direction' (Hutt, 1975 B, p. 92). Studies revealing these are Newcombe et al. (1975) on block design, on mazes (Davies, 1965) and on rotary pursuit tasks (Shephard, Abbey and Humphries, 1962. In this study however, sex differences were not significant). I have not been able to find a reference referring to a sense of direction for adults and this ability will be discussed at greater length in the results of my own study. Furthermore there are many references to intersex differences in favour of males on tests of mechanical aptitude, (see e.g. Buffery and Gray, 1972, p. 126). In how much tests such as these are measures of spatial ability will be a central topic of this study.

However other tests which might appear equally 'spatial' but do not show sex differences are the DAT abstract reasoning test (Bennett et al., 1968) which as Fairweather (1976) notes contains discriminada of a basically spatial nature (p. 250)[1], Raven's matrices, and problem solving with spatial components (Wood and Wood, 1975).

Sex Differences in Spatial Ability in Children

(a) As far as I have been able to ascertain there are no standardised tests of spatial ability suitable for children below the age of about twelve. Again there is no reference in the literature to results of studies on especially designed spatial tests for children below this age group except for the study made by Karnovsky (1974). She tested 445 children on two spatial rotation tests and found no significant sex differences on grades one, two and four. Sex differences appeared at grade seven and resulted from the relatively poor performance

1. Witkin often uses a third test to measure field independence, the Draw-a-person test. Performance on this test, on which sex differences are seldom consistent has also been shown to be closely related to artistic ability (Solar et al., 1970, Mayo and Bell, 1972).

of grade seven girls in comparison with the younger girls. Furthermore among seventh grade children, significant sex differences were confined to those subjects in low and medium mathematics classes. Among seventh grade children in higher maths classes there were no sex differences on either of the spatial tests.

Karnovsky's findings are in agreement with Fairweather's contention (1976, p. 250) that 'Emergence of a male superiority on the defined spatial scales appears to coincide almost exactly with adolescence'. This is in accordance with my own inspection of the literature as well.

The earliest age at which I have been able to document an intersex difference on defined spatial scales is 13. This is in the oft-quoted 1948 Mcfarlane Smith study with 100 Scottish schoolchildren aged between 12½ and 14½. He found consistent differences on a battery of spatial tests in favour of boys.

On the norm tables of the DAT space relations test small intersex differences are apparent at the youngest age (grade 8) and these tend to amplify with age as girls' scores show less improvement with age than boys'. Table 1 summarises the result of a standardisation done with Form L of the test.

TABLE 1: SPACE RELATIONS ON THE DAT FORM L (Bennett et al., 1968 pp 3 - 13 to 3 - 17)

	GRADES				
	8	9	10	11	12
50th percentile					
male	22-23	26-27	31-32	34-35	36-37
female	21	25-26	27-28	30	31-32
n	4800	6150	5600	4600	3850

In a recent large study with 2508 San Francisco school children (grades 9 - 12) Yen (1975) showed similar results. On four spatial tests girls scored significantly lower. But a considerable proportion of the boys' superiority is attributable to the fact that only they show significant improvements with age. On all tests girls' scores declined in grade 11 relative to grade 10.

In summary then sex difference on standardised scales appear at adolescence and appear to widen with age.

(b) On tests of field independence findings are not consistent for children with respect to sex differences. I will consider those on embedded figures first. Various tests of embedded figures have been used all falling within the description noted on page 10. The most commonly used are the PEFT (pre-school embedded figures test, Coates, 1974) and the CEFT (children's embedded figure test, Karp and Konstadt, 1963).

Results on the PEFT are summarised by Coates (1974). Of the nine studies surveyed significent sex differences in favour of girls were shown on six and in three no sex differences were shown. All nine studies were on pre-school children.

Results on older children using the CEFT seldom show sex differences. Cecchini and Pizzamiglio (1975) showed none for children aged four to ten years. Bowd (1976) surveyed the literature on CEFT and concluded that this showed a consistent absence of sex differences. He replicated this himself with a sample of Canadian children. Results on yet older children using the EFT are inconsistent. For example Trent (1974) showed no difference with children in grades 11 and 12 but Wolf (1971) using his own version of the EFT on the same age group did show sex differences.

On the rod-and-frame test comparatively few studies relate to children and results on these are not consistent either. For example Saarni (1973) found sex differences in favour of boys with a sample of 64 school children (mean age 13 years) but Witkin et al. (1967) found no significant sex differences with a group tested at 10, 14 and 17 years.

(c) As I mentioned in the preceding section on sex differences in spatial ability with adult subjects, reviews on sex differences in this field often refer to tasks that, although not originally designed as tests of spatial ability, are thought of as having large spatial components. As with adults sex differences on mazes in favour of males are often quoted (Fairweather, 1976, Wilson 1975), so is block design though here the difference is in favour of girls (Fairweather, 1976, quoting a WPPSI standardisation).

Two individual studies that have received some attention are Lord's (1941) and Keogh's (1971, 1972). Lord showed that boys were superior at pointing out compass directions and also that boys had a better sense of direction. Keogh's study showed that while boys were not better at copying patterns with pen and paper, they were better at copying them if they walked the patterns. Both these studies will be referred to again in the next chapter.

Cross-cultural Studies in Intersex Differences in Spatial Ability

In considering, as I shall do in the next section, theories accounting for sex differences in spatial ability, cross-cultural studies provide a highly relevant source of data. As in the two preceding sections I shall present the studies in three subsections.

(a) I have been unable to find any relevant studies using standardised spatial tests in a non-western European or American setting. For example in Vernon's definitive cross-cultural study of intelligence, Intelligence and the Cultural Environment, (Vernon, 1969), only male subjects were used.

(b) As Maccoby and Jacklin note (1974, page 129) 'cross-cultural work on intellectual abilities (especially as it relates to sex differences) seems to have focussed upon the field dependence/field independence dimension'. Table 2 summarises the studies I have been able to locate.

TABLE 2: CROSS-CULTURAL RESULTS ON INTERSEXUAL DIFFERENCES ON MEASURES OF FIELD INDEPENDENCE

(Where differences are indicated these are in the direction of males being more field independent.)

Culture	Source	EFT	RFT
Eskimo	Berry (1966)	no	-
	McArthur (1967)	no	-
Nigeria (rural)	Okonji (1969)	yes*	no
Nigeria (undergraduates)	Okonji (1969)	no	yes
Sierre Leone	Berry (1966)	yes*	-
South Africa (rural)	Du Preez (1968)	-	no
Japan	Kato (quoted by Witkin & Berry, 1975)	-	yes
India	Pande (1970)	yes	-
Hong Kong	Witkin and Berry (1975)	yes	no
Mexico	Mebane and Johnson (1970)	yes	-
Zambia	Siann (1970)	no	no

- indicates no results

* indicates interaction with years of education

Table 2 seems to show once again that results on field independence are not consistent with regard to sex differences.

(c) Berry (1966) conducted a cross-cultural study in Scotland, Sierre Leone and amongst Eskimos. He used four tests which he labelled as 'spatial' and accordingly I shall consider them in this section. The measures were Koh's blocks, Raven's matrices, EFT and Morrisby shapes[1]. In each of the three cultural groups he tested two samples - one living in more rural, traditional communities, and the other in what he called 'transitional' communities in Sierre Leone and amongst the Eskimos, and urban in the case of the Scottish sample. For the Eskimo sample, no significant sex differences were shown in the eight intersex comparisons and no directional trend was clear either. For the Sierre Leone sample four out of the eight intersex comparisons showed a significant sex difference in favour of men and two others were directionally in favour of men. In the Scottish sample four were significantly in favour of men and the other four directionally so[2].

1. Morrisby shapes - unlike the other three tests used these are a standard test of spatial ability (See Morrisby, 1955).
2. Berry performed a similar study with Annis (1974) using four Amerindian groups. On this occasion they investigated psychological differentiation (Witkin et al., 1962) - the extent to which an individual

Dawson et al. (1974) showed sex differences amongst children on a pictorial depth perception level with 452 Hong Kong Chinese children. Sex differences were not shown between the ages six years to seven and a half years but thereafter they increased with age.

Summary on Sex Differences in Spatial Ability

In summary I think the following conclusions can be drawn from the data described:

Consistent sex differences in favour of men are shown for:

1. Adults on tests specifically designed to measure spatial ability, (e.g. the Guilford-Zimmerman tests and the DAT).
2. Children older than 13/14 years on standardised spatial tests; these differences appear to increase with age mainly due to the fact that girls' scores tend to remain static or decline while boys' scores improve.

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shows field independence at both the perceptual and personality level. For the perceptual level they used Koh's blocks and Raven's matrices but unfortunately in reporting the intersex differences the authors do not distinguish between the personality and perceptual measures viz 'In the present study point biserial correlations between sex and the five differentiation tasks show no overall relationship...' (p. 190).

With respect to the other tests discussed, i.e. tests of field independence and those not specifically designed to measure spatial ability but regarded as having a high spatial component (henceforth to be referred to a 'quasi' spatial tests) findings are not so clear cut:

3. On tests of field independence and on 'quasi' spatial tests men in the West tend to do better than women though this finding is not consistent.
4. On tests of field independence and on 'quasi' spatial tests children do not show sex differences that are at all consistent.
5. On tests of field independence and on 'quasi' spatial tests non-Western adult populations do not show consistent sex differences.

In the next section I shall be discussing theories postulated to account for sex differences in spatial ability. In each case I shall consider how well these theories can accommodate the five findings listed.

Table 3 tabulates the summary points and will be updated as the theories are treated in the next chapter.

TABLE 3: RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P. etc.	Laterality (m. bi-lat.)	(f. bi-lat.)	Recessive Gene	Hormones
I Western Adults						
Sp. tests (m >)						
II Children						
Sp. tests						
(m>after 13)						
III Western Adults						
F.I. and q-sp. tests						
(m > mostly)						
IV Children						
F.I. and q-sp. tests						
(n.c.d.)						
V Cross-cultural						
F.I. and q-sp. tests						
(n.c.d.)						

KEY F.I. field independence; sp. spatial; m/f bi-lat. males/females more bi-lateral

D.P. differential practice; q-sp. quasi-spatial; m> males score higher; n.c.d. no consistent difference

Discussion

In this chapter, I have attempted to summarise and systematise those studies I have read on sex differences in spatial ability. The reader may note, with some surprise, that despite the supposed consistency of sex differences in this area (see, for example, the quotations listed on pp 6 - 7) males do not always perform better in tests of spatial ability. One of the chief aims of the present study is to account for these inconsistencies. However, before attempting to do so, I would like to discuss some of the theoretical perspectives that have been proposed to account for sex differences in this area and in doing so I shall also consider how adequately the perspectives accommodate the inconsistencies.

CHAPTER TWO : THEORIES ACCOUNTING FOR SEX DIFFERENCES IN SPATIAL ABILITY

Lloyd (1976) in writing of explanations offered of sex differences notes that 'Although the heated nature-nurture debates of the past have been replaced by a general recognition that neither of these sources are sufficient alone to explain development, controversy still flares about the explanation of sex differences' (p 10). As I noted on pages 2-3 she identifies two perspectives - biological determinism and the interactional. I shall consider the theories within this framework, adding a third catagory - social conditioning. As I discuss the individual theoretical explanations, I shall expand on a summary table my five points (Tables 3A to 3G). It will be noted that this table does not refer to all the explanations as some discussed will be shown to be inadequately based.

Social Conditioning: Theory I: Field Independence

Witkin and Berry (1975) have proposed that observed sex differences on spatial tests can be subsumed under sex differences in field independence. They see performance at tasks involving spatial ability as being determined primarily by the 'cognitive style' of the individual.

Cognitive styles themselves are manifestations in the cognitive sphere of 'still broader dimensions of personal functioning' (Witkin, 1967, p.234) and are the end products of particular socialisation practices. Subjects who perform well at spatial tasks are able to perceive items as discrete from the organised ground; they are 'field independent' and this articulated approach characterises the whole psychological functioning of the individual. Witkin explains the inferior performance of women at spatial tasks in two main ways. Firstly it is conjectured that the socialisation practices for girls are different from those of boys and less inclined to produce field independence - specifically girls are given less training for independence than boys, also less stress is placed on achievement and assertiveness for girls than boys and thus girls follow a pattern of socialisation thought by Witkin and his associates to produce field dependent individuals. Witkin (1966) suggests further that because female sexual organs are 'hidden' (p.107) whereas men's are 'visible' girls find it more difficult to achieve a clear concept of their bodies 'thereby fostering greater reliance on the field -- that is more field-dependent perception' (p. 107). However the main emphasis is on the differing socialisation practices for boys and girls.

Witkin and his associates have extended their theory of field independence to non-Western cultures as well. They claim that field dependency will be more marked in a culture where there is more emphasis upon conformity, more reliance upon authority and restriction of the individual's autonomy. Societies which encourage independence, on the other hand, will tend to produce more field independent individuals. Thus Berry's studies referred to on pages 19-20 were an attempt to rank societies according to the level of independence encouraged and to relate this ranking to scores on tests of field independence and differentiation.

I shall first consider Witkin's theory in relation to the five summary points on sex differences on spatial ability (pp 20-21) and then make some detailed criticisms of the theory that are not directly related to sex differences but that throw some doubt on the reliability of the RFT test and that question the adequacy of the concept of field independence.

Summary point (1) dealt with the consistent sex differences in favour of men on standardised tests of spatial ability. Witkin's theory accommodates this by supposing that the underlying variance on these tests is due to field independence, and men are higher in this latter quality due to their more autonomous cognitive style which itself is related to socialisation practices. Point 3 deals with observed sex differences on adults in the West on tests of field independence in favour of men and the theory accounts for this in terms of its central premise that such differences are due to differing socialisation practices. Similarly with respect to 'quasi' spatial tests results favouring men can be interpreted in terms of the test content being high on measures of field independence. Results on children are less well accommodated by the theory. Dealing first with the non-consistent differences on tests of field independence, I see no reason for the lack of consistent sex differences on this measure when there are clearly individual differences. If these individual differences are due to different socialisation practices and sex differences are also, at a later age, predicated on differences in socialisation practices, then surely as individual differences emerge so should sex differences. Similarly in as much as sex differences in spatial ability shown on spatial and 'quasi' spatial tests are ascribed by the theory as due to the underlying field independence component of these tests, as individual differences are shown so should sex differences be. In summary then the results on children's studies are not well accounted for by the theory.

The cross-cultural results, however, are well accommodated by the theory. The inconsistencies in these are explained in terms of the differing socialisation practices of different cultures. Berry has established a relationship between cultures with high sexual stratification in roles (e.g., Scottish, and to a lesser degree, Temne) and consistent sex differences in field independence and cultures with low sexual stratification in roles (e.g., Eskimo and Cree) and a lack of sex differences on tests of field independence.

Table 3A summarises how well Witkin's theory accommodates the five findings. Thus Witkin and Berry's theory accommodates three of the five summary points. However I have some more fundamental criticisms to make of Witkin's theory. Two of these relate to the reliability of his chief measure of field independence (the rod-and-frame test) and the third relates to a more fundamental question about the nature of field independence as a concept.

Reliability of the Rod-and-frame Apparatus and Administrative Procedure

One study reported using an instrument which yielded such a low deviation from the correct response that no differentiation between field independent/field dependent subjects was possible (Stuart and Bronzaft,

TABLE 3A RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P. etc.	Laterality (m. bi-lat.)	(f. bi-lat.)	Recessive Gene	Hormones
I Western Adults	Well accommodated					
Sp. tests (m >)						
II Children	Not very well					
Sp. tests	accommodated					
(m > after 13)						
III Western Adults	Inconsistent results					
F.I. and q-sp. tests	on EFT and RFT - not					
(m > mostly)	well accommodated					
IV Children	Not very well					
F.I. and q-sp. tests	accommodated - particularly					
(n.c.d.)	inconsistent results on EFT and RFT					
V Cross-cultural	Well accommodated					
F.I. and q-sp. tests						
(n.c.d.)						

KEY F.I. = field independence sp. = spatial m/f bi-lat. = males/females more bi-lateral

D.P. = differential practice q-sp. = quasi-spatial m> = males score higher n.c.d. = no consistent difference

1970). A second portable version of this correcting the disadvantages (light reflected from the calibrated scale in the rear of the instrument as well as from its illuminated face) yielded results that were not consistent with the literature (Stuart and Murgatroyd, 1971). Both studies taken together, however, illustrate how easily incidental peripheral cues in any portable version, may influence responses.

The method of presentation of trials may also affect subjects' score distributions. Fifty female undergraduates (Lester, 1967) were tested with five versions of the rod-and-frame test, each randomly assigned to five groups. Each of the five procedures was intended to vary the implicit information available to subjects by varying the tilt of rod-and-frame. A further variable factor was the presence or absence of control readings without the frame. One method yielded significantly lower error scores, as well; the author was not able to offer an explanation of these results.

In a discussion by Handel (1972) the following general factors were summarised which appear to affect overall response patterns: the uncertainty of perceptual set; the implicitly error-producing cues contained in confronting subjects with tilted frames only; the basic difference between experimenter operated condition and subject operated conditions; the effect of instructions which lay differential stress on the gravitational vertical. Further, Cabe (1968) showed that method of scoring also produces variance. In general, then, it appears that measurements of field independence by the rod-and-frame test are not always reliable.

(2) Factors affecting the Response of Subjects

Shifts in field dependence as measured by RFT can be affected by continued change in sensory experience (Astrup, 1968). Subjects' scores may also be affected by differential attention to bodily cues (Klepper, 1969), by visual exposure time (Morant and Aronoff, 1966) (but only in the rod alone and frame alone conditions), by social background and perceptual experience (Vaughn, 1971) and see also Siann (1972).

These studies appear to indicate that individual performance at RFT may be related to specific factors associated with the test situation and to recent perceptual experience.

(3) What RFT Measures: the Concept of Field Dependence

In the last few years, many articles have appeared which question Witkin's claim that RFT and the embedded figure test measure the same thing (field independence) and may be used interchangeably. Notably Vernon concluded after a large scale factorial investigation that while RFT may involve a distinctive visuokinesthetic factor, it shares no variance with EFT that is not attributable to either general intelligence or spatial ability.

Another study (Denmark et al., 1971) has indicated in the past spuriously high correlations have been obtained by using extreme scores for RFT and EFT. On the other hand a review article (Aburthnot, 1972) summarising the relationship between frequently used measures of field independence (including RFT and EFT) in forty studies showed that while the measures did share some variance 'the amount is generally quite low'. The author of this review cautions that field independence should only be measured by the combined use of RFT and 'either Witkin's original EFT or Jackson's shortened version thereof' (p. 479). However Vernon's study referred to above, in which these measures were used, accounted for the common variance between these in terms of 'g' and 'S' only.

Wachtel (1972) in a comprehensive review article on field independence concludes that in the past researchers have not distinguished between differences in field dependence relating to differences in ability and those stemming from adaptive choice and strategy. Dubois and Cohen (1970) like Vernon were concerned with the relationship between measures of psychological differentiation and intellectual ability. They measured 143 female undergraduates on RFT and EFT and a variety of other academic abilities. They obtained a correlation of .56 between RFT and EFT but this was no greater than that obtained between EFT and Maths achievement or the total of all ability scores and EFT. They conclude their discussion thus, (p. 145), 'At this point we feel that a considerable gap still exists between the empirical findings on field independence and their adequate conceptualisation. The dimension, which is certainly not very clearly explained, at this point, may yet hold unexpected significance as a broader explanatory construct in human perception and behaviour. <u>On the other hand, field independence may some day be thought of simply as one factor of intelligence</u>', (my emphasis).

Finally a short reference to the use of the field independence concept in psychopathology. Witkin has claimed that perceptual field dependence is a global trait that cuts across levels of intelligence and psychopathology in a meaningful way. Testing sixty randomly selected patients and thirty therapists Vardy and Greenstein (1972) found that subdividing the patients along the lines of psychopathology suggested by Witkin failed to show significent differences in test performance. They concluded by challenging the adequacy of this simple two dimensional category to meaningfully differentiate between patient populations.

In conclusion then it can be seen that the concept of field independence is coming under increasingly frequent criticism. Nevertheless, Witkin's work does suggest an interesting perspective in looking at sex differences over a wide range of psychological functioning and I shall discuss the implications of this perspective in Chapter 9.

Social Conditioning, Theory 2. Differential Expectation and Practice

In 1970 I put forward this theory to account for observed differences in spatial ability. It was postulated that the main reasons for sex differences in spatial ability were (i) differential expectation and (ii) differential practice. Furthermore it was suggested that the tests of spatial ability that are used tend to be sex-biased to the extent that normally geometric shapes are used and girls tend to regard geometry as a masculine subject.

With respect to differential expectation I suggested that it has been traditional in Western Europe to regard the professions of engineering and architecture, both of which require a large measure of spatial ability, as not particularly suited to women. Those women architects that I had contact with had experienced a great deal of prejudice within the profession. In addition girls are not expected to perform as well as boys at mathematics, particularly applied mathematics.

It was suggested that this difference in expectation led to two main types of effect. In the first case girls themselves are led to expect a lower rate of performance from themselves at tests involving geometric shapes than their boy peers are, thus differences in motivational levels occur. Secondly as Sherman (1967) pointed out this difference in expectation leads to differences in practice. It was argued that this may even be seen in the choice of toys. It is less common for girls to receive constructional toys (e.g., Lego, Meccano) than it is for boys. In general within the school system in Western countries these differences are further entrenched; boys tend to attend woodwork and technical drawing classes whereas girls attend classes in domestic science.

That spatial tasks tend to be sex biased was a suggestion that was put forward tentatively at the outset of my 1970 study. Such a sex bias had previously been shown by Milton (1957) for Duncker-type problems. Milton asked sixty Stanford undergraduates (30 male, 30 female) to report on the type of problems they encountered in everyday life, the resulting problems were categorised by two independent judges for each sex group. Following this, typical problems based on Duncker were given to two other independent judges with instructions to categorise them into the categories developed in the initial study, and for one judge 77% of the problems were masculine and for the other judge 83%. Chi-square was significant beyond the .01 level in both cases and the inter-judge reliability was .72. Following this two parallel sets of problems were devised. One set was in the form conventional to problem-solving literature, the other was more appropriate to the feminine role, and these were presented to 50 undergraduates (25 male and 25 female). Analysis of variance indicated significant interaction effects for sex problem content ($p \leq 0.05$). It was postulated that the test content of spatial tests was similarly biased. In summary then this theory relates observed sex differences on spatial tests to the cumulative effects of differential practice and expectation and sex-biased stimuli.

I shall first relate this theory to the five points summarised on pages 20-21 (see Table 3B) and shall then refer to two sets of results bearing on the theory.

The first summary point dealt with established male differences in standardised tests of spatial ability. This theory would explain these differences in terms of differential expectation and practice. Point 2, the emergence of sex differences at 13 years of age can be understood in terms of the slowly accumulating effect of differential practice and expectation and further the decline in girls' scores at about 16 years (Yen, 1975B) can be explained in terms of increasing gender stereotypes and sex-role expectation. Point 3, the tendency for adult Western males to score better at tests of field independence and at 'quasi' spatial tests is also accommodated relatively well by the theory. These tests would also be subject, in view of their content, to expectation and practice effects.

Point 4, (inconsistent results for children on tests of field independence and on 'quasi' spatial tests) can be explained as follows: to the extent that individual tests would be affected to a greater or lesser extent by practice and expectation effects, one would expect sex differences to be inconsistent for children. With respect to cross-cultural studies, the theory would predict that the more westernised the culture, the more likely it would be for sex differences to occur. Table 2 (page 18) lends some support to this, in that rural samples and cultures that are relatively free from Western influence (e.g. Eskimos) are less likely to show sex differences and urban samples and societies more influenced by Western educational practice (e.g. India) are more likely to show sex differences. But the fit is by no means perfect.

It will be seen that this theory accommodates the data reasonably well. The chief criticism to be made of it is that it is largely speculative and until the effects of differential practice and expectation are shown the theory must remain unproven. In the study to be reported an attempt is made to test some of the hypotheses arising from this theory. However I can report at this stage two sets of results that have some bearing on this theory. In the first case, my 1970 study investigated interaction effects for sex appropriate stimuli (see pp 571-573 for examples) and sex of subject. In two out of three studies the interaction was significant lending a little support to the theory. The second finding did not lend support to the theory.

This study (Siann, 1975) investigated DAT space relations scores for 55 social and community work students. In terms of the theory I predicted that sex differences on this sample would not be shown in that gender roles and expectations would not be firmly held for students in these professions. In fact strong sex differences were shown in favour of males ($t = 2.75$, $p \leq .005$).

Biological Determinism: Differential Lateralisation Patterns for the Sexes

The functional division of the brain into dominant and non-dominant hemispheres appears to be an evolutionary change that is related to the development of language (Hamburg, 1974). Much clinical evidence indicates that speech and language are located in the dominant (normally left hemisphere. With reference to the topic under discussion I now wish to present two differing viewpoints as to the hemispheric localisation of spatial skills. Both viewpoints agree on one proposition, however, and that is that sex differences in spatial ability can be related to differing intersexual patterns of lateralisation of this skill.

TABLE 3B RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning	THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P.etc.	Laterality (m. bi-lat.) (f. bi-lat.)	Recessive Gene	Hormones
I Western Adults Sp. tests (m>)	**	Well accommodated			
II Children Sp. tests (m> after 13)	-	Well accommodated			
III Western Adults F.I. and q-sp. tests (m>mostly)	*	Well accommodated			
IV Children F.I. and q-sp. tests (n.c.d.)	-	Well accommodated			
V Crosscultural F.I. and q-sp. tests (n c.d.)	**	Reasonably well accommodated			

KEY F.I. field independence   sp. spatial   m/f bi-lat. males/females more bi-lateral

D.P. differential practice   q-sp. quasi-spatial   n.c.d. no consistent difference   m > males score higher

** well accommodated   * reasonably well accommodated   - not well accommodated

Differential Lateralisation Theory 1 - High Spatial Ability is related to the Bilateral Processing of Spatial Tasks

This theory receives its fullest statement in the work of Buffery and Gray (1972). They propose a developmental and neuro-physiological model for intersex differences on spatial ability. This may be summed up in four propositions and after stating them, I shall discuss each in turn:

1. The human brain has an innate species-specific and lateralised (usually left-sided) neural mechanism. This neural mechanism in combination with proximate neural structures leads to the development of a cerebral hemisphere dominant for language.
2. This neural mechanism which is specialised for speech perception, is more developed in the female than in the male brain of the same age. This has two major consequences:
3. Lateralisation of cerebral dominance for verbal skills is accelerated in the female brain, facilitating the development of linguistic skill in women.
4. A more bilateral cerebral representation for non-verbal function is established in the male than in the female brain 'and such functional topography facilitates the development of spatial skill in men' (p. 147).

With respect to their first proposition there is little disagreement (see e.g. Zangwill, 1976).

Proposition 2 implies that females are more lateralised in brain function than males and that this lateralisation takes place earlier in them than it does in males. The contention rests on two experimental studies done by Buffery (1970, 1971)[1]. One hundred and sixty right-handed children were asked to perform the Conflict Drawing Test. The children were aged three years to almost eleven years in age. The test requires them to draw simultaneously with their eyes closed a square with one hand and a circle with the other. Results showed that the majority of girls in all age groups exhibited a non-preferred left hand superiority for the drawing of a well proportioned square whereas boys showed this superiority only after seven years of age. Further the girls showed a greater precocity than boys in their right hand preference. Both these findings are taken as indicating earlier and stronger lateralisation for girls than boys. Another study by Young and Ellis

1. In addition some support is offered indirectly by studies (e.g. Richardson, 1975, see also Hutt, 1975A) indicating that relative to girls, boys suffer a developmental lag. Fairweather however, contests these findings (see Fairweather 1976, pp 234-235).

(1976) also claims to offer some support for this proposition. They worked with children aged five years to eleven years. The children were shown faces presented briefly to their left visual and right visual field. After a short interval they were asked whether a comparison face was the same as the one they had just seen. Some children however were discarded because their responses on a pre-test indicated that they had better performance with stimuli presented to either periphery than they did to stimuli presented centrally. These children were thought to display a greater degree of 'hemispheric competition' and more of these children were boys. Thus Young and Ellis offer support to Buffery and Gray's claim that boys have a more bilateral cerebral representation of spatial function than girls of the same age (p. 407).

However both these studies are weakened by inadequate documentation. In the case of the Buffery study just described (and in the case of the very similar one also cited) description of the rating procedure is confined to the remark that superiority of drawing was 'measured by the <u>actual</u> squares deviation from an <u>ideal</u> square constructed in relation to the first line drawn of the square' (Buffery and Gray, 1972, p. 142, their italics). No mention is made of who did the rating or rater reliability. In the Young and Ellis study they mention that more boys than girls were discarded according to their criterion. Actual inspection of their figures reveal that 20 boys out of 41 were discarded and 9 girls out of 30. This is not a significant difference in frequency.

In summary the proposition does receive some support from the studies described and from the suggestion that, relative to girls, boys are slower in their overall development. However replication of Buffery's studies with a more rigorous methodology would add further weight to the argument.

Proposition 3 can be related to the studies investigating sex differences in linguistic skills. As was indicated on pages 3-5 these studies are by no means consistent. However even if clear cut differences were established in linguistic skills, these could not necessarily be ascribed to differences in lateralisation. Some interaction with social expectations and practices would also have to be taken into account. However the earlier the differences manifest themselves, the less likely they are to be social in origin. The only large scale studies on young children were done in the 1930's and 1940's. These show directional though not always significant superiority for girls under the age of three, (Maccoby and Jacklin, 1974, p. 75). However Maccoby and Jacklin continue that 'recent, relatively small scale studies seem to indicate that the presumed advantage of girls in the first two years of life is tenuous' (p. 77).

We must conclude then that though proposition 3 does receive some support in that early sex differences in linguistic skills tend to be in favour of girls, the contention that these are due to differential rates of lateralisation remains unproven. Perhaps cross-cultural studies, if they show similar effects, could rule out social and interactional effects.

With respect to proposition 4 Buffery and Gray offer no supporting evidence at all and I have been unable to find any studies that show high spatial ability to be associated with bilateral processing or that men process spatial tasks more bilaterally. Indeed as will be seen in the next section, ambilaterality seems to be more a function of female spatial processing. However I will quote directly from Buffery and Gray's most amplified exposition of proposition 4 to show that this tends to be both speculative and unreferenced (1972, p. 144). 'Sex differences in the lateralisation of cerebral dominance for linguistic skills may contribute to the general finding of a female superiority in verbal tasks and a male superiority in non-verbal and, in particular, spatial tasks. Linguistic skill, with its need for quick associations and serial ordering, probably demands fast and intricate neural mechanisms. Such mechanisms could benefit from being subserved by specific structures with a clearly lateralised and localised cerebral representation. This is apparently more likely in the female than the male brain. Spatial skill, however, which is usually exercised in a three dimensional and completely enclosing world may benefit from bilateral representation. Thus a consequence of the less well lateralised cerebral representation of linguistic skill in the male brain might be a more bilateral cerebral representation of spatial skill than can be achieved in the female brain. This is on the assumption that whatever language functions are subserved by areas of a non-dominant hemisphere leave equivalent areas in the dominant hemispheres free to subserve non-verbal functions. In both sexes there will usually be a predominance of spatial function in one cerebral hemisphere or the other, but in general the male brain has, because of its less well lateralised language function, a better opportunity to develop a more bilateral and therefore a more efficient spatial function.'

Having discussed Buffery and Gray's theory in outline, I will now show, with reference to Table 3C, how adequately it accounts for the five summary points I made on page 20-21 of studies of sex differences in spatial ability. With respect to points 1 and 3 the theory accommodates well to the findings. Adult male Western superiority on tests of spatial ability, field independence and on 'quasi' spatial tests can clearly be ascribed to different patterns of lateralisation. Points 2 and 4 showing inconsistent sex differences for children on these tests are less easy to accommodate. Different patterns of lateralisation for the sexes are considered by Buffery and Gray to occur at infancy (although presumably they are thought to develop with experience). Therefore sex differences in spatial ability should reveal themselves as soon as (or soon after) individual differences on these measures are shown. Point 5 dealing with inconsistent differences in non-western subjects on these tests is also more difficult for the the theory to account for because presumably the differences in lateralisation discussed by Buffery and Gray should apply to all members of the human race.

In general it can be stated that this theory in terms of its general statement is still largely speculative and further it does not fit

TABLE 3C RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism	
FINDINGS	F.I.	D.P. etc.	Laterality (m. bi-lat) (f. bi-lat.)	Recessive Gene	Hormones
I Western Adults Sp. tests (m >)	**	**	Well accommodated		
II Children Sp. tests (m> after 13)	-	**	Depends on when laterality is regarded as being established		
III Western Adults F.I. and q-sp. tests (m > mostly)	*	**	Well accommodated		
IV Children F.I. and q-sp. tests (n.c.d.)	-	**	Depends on when laterality is regarded as being established		
V Cross-cultural F.I. and q-sp. tests (n.c.d.)	**	*	Not well accommodated		

KEY F.I. field independence sp. spatial m/f bi-lat. males/females more bilateral

D.P. differential practice q-sp. quasi-spatial n.c.d. no consistent difference m > males score higher

** well accommodated * reasonably well accommodated - not well accommodated

documented findings very well.

Differential Lateralisation Theory 2: High Spatial Ability is related to Right Hemisphere processing of Spatial Tasks

A number of researchers have postulated an explanation for sex differences in visuo-spatial ability that is also based on differences in lateralisation but that runs directly contrary to Buffery and Gray's theory. They suggest that male superiority in spatial tasks stems from the greater specialisation of the two hemispheres for males. This hypothesis is based on two lines of research. Firstly some studies have shown that men display greater superiority for right hemisphere processing of visuo-spatial tasks than women do, (e.g. Kimura, 1969, McGlone and Davidson, 1973). Secondly Sperry and his colleagues working with patients in whom the functional connections between the two hemispheres have been severed, have argued that the localisation of verbal functions in the left hemisphere and spatial functions in the right appears to be weaker in women (Levy Agresti, 1968).

I would like to consider this explanation for sex differences under the following headings:

1. Do studies consistently show men to be more lateralised for

visuo-spatial tasks?

2. Does the nature of the visuo-spatial task affect lateralisation of processing?

3. Have subjects who have been shown to be more right-sided lateralised for spatial tasks than other subjects, also been shown to score higher on tests of spatial ability?

4. Do the lateralisation patterns observed in left-handed as opposed to right-handed subjects bear on the explanation?

1. Studies showing Lateralisation Effects on Visuo-spatial Tasks for both Sexes

Davidoff (1977) summarised the literature for hemispheric differences in visuo-spatial tasks. He included only those studies that showed some degree of hemispheric advantage, that used both sexes and that partitioned the data for the sexes. Of the twenty one studies that met these criteria:

eight reported greater right-sided superiority for males. It should be noted that three of the studies were on clinical subjects.

Two reported greater left-side superiority for men.

One reported greater right-side superiority for females (this was the conflict-drawing test of Buffery (1970, 1971) which I have already discussed).

Ten reported no difference between the sexes with respect to patterns of lateralisation.

These 21 studies ranged from simple decisions as to the subjective brightness of two circles (Dallenbach, 1923) through two-dimensional tasks such as the localisation of dots in a two-dimensional array (Kimura, 1969 to psychometric tests (e.g. the Block design, McGlone and Kertes, 1973).

It will be seen that where sex differences are reported they tend to lie in the direction predicted by the theory.

In discussing these effects, many researchers (e.g. Witelson, 1976, McGlone, 1976) appear to regard women as more likely to use bilateral processing of the tasks under consideration.

Witelson studied 200 right-handed children aged six to thirteen years using tactile perception of spatial parameters. The test required the children to palpate simultaneously, out of view, two different meaningless shapes for ten seconds. Then the subjects were asked to choose these shapes from a visual display. She found that while boys were not more accurate than girls, they did show greater accuracy for their own left hand score than for their right hand score and this effect held even with the youngest age group. She argued that superiority of the left hand on this dihaptic test reflected superiority of the right hemisphere for spatial processing and that these results 'suggest that for boys of at least six the right hemisphere is more specialised than the left for spatial processing; in girls, however, there is bilateral representation at least until adolescence' (p. 426).

Similarly McGlone reports that studies with patients with unilateral lesions of the left or right hemisphere, also indicate the women process more bilaterally than men; 'Men clearly show the expected pattern of: (1) impaired verbal abilities following left-sided lesions, and (2) impaired spatial abilities following right sided lesions .... In women language deficits are less common and less severe after left sided injury, and visuo-spatial disorders occur equally often after left or right sided lesions. These data suggest more unilateral organisation of speech and spatial function in men compared with women (p. 148).

In summary then there does seem some support for the contention that for women bilateral processing of some visuo-spatial tasks does occur and that men are more lateralised in the right hemisphere for these tasks.

2. The Nature of the Visuo-Spatial Task and Lateralisation

Maccoby and Jacklin (1974) write (p. 126) 'Some puzzling questions arise from the work on cerebral lateralisation in the two sexes. One is that the 'package' of skills localised in each hemisphere do not correspond in detail to the known sex differences in ability. Levy-Agresti (1968) for example, has described the left hemispheres as being verbal, sequentially detailed, analytic and computer-like. This description of left hemisphere processing covers cognitive skills that are clearly involved in many standardised spatial tests which a glance at pages 537 - 564 of this study should indicate. It will be seen that for the DAT space relations and the two Guilford Zimmerman space tests a large component of sequentially detailed and analytic skill is required.

Similarly returning to the McGlone paper quoted in the preceding section, it is of interest to note that the 'spatial abilities' referred to were represented by the WAIS performance sub-tests and it is at least arguable that these too require analytic and sequentially detailed abilities.

However even using simple visuo-spatial tasks lateralisation effects are sometimes not clear-cut. In three studies using students (12 males and 12 females in each) Patterson and Bradshaw (1975) report that in an easy discrimination task there was an interaction between judgement same/different and visual fields. Judgements same were performed faster to stimuli in the left visual field, and there was a non-significant difference in the opposite direction (i.e. for the right visual field and therefore the left hemisphere) for judgements different.

Another variable affecting which hemisphere was superior in processing was task difficulty. Thus when a test configuration was compared with a previously stored pattern in an easy task in which all three features differed, the left visual field (i.e. right hemisphere) proved superior for both judgements same and different. However in a more difficult task in which the test stimulus differed in only one feature from the previously stored target (incidentally a task far more similar to most standardised space test items) the right visual field (therefore left hemisphere) proved superior, for both judgements same and different Patterson and Bradshaw interpret their results as supporting the following proposition; 'the analytic/gestalt dichotomy in processing may be a more fundamental difference in hemispheric function than that of language/visuospatial analysis' (pp 251-252).

In summary then it is my contention in this section to suggest that a simple dichotomy in which spatial tasks are seen as best being processed in the right hemisphere and verbal best in the left is too simplistic a view. Further the work of Tucker (1975) using EEG traces to indicate hemispheric processing supports this as he notes in his study with a student population that both sexes rely upon both hemispheres when perceptual analysis is required.

3. The Link between Lateralisation for Visuo-Spatial Tasks and Spatial Ability

If the explanation for sex differences lies in the greater lateralisation for males or visuo-spatial then a link between a high degree of lateralisation and high spatial ability should be demonstrable.

I have only been able to find two published studies that sought to demonstrate such a link (and in the first of these only incidentally to the main question under consideration in the study concerned).

The first study by McGlone and Davidson (1973) used a sample of sixty six students and in the analysis to be described did not partial out the sex of the subjects. They showed a link between scoring above the median on the PNA space relations tests and left visual field superiority for dot enumeration. This was demonstrated by a χ^2 test and was significant only at the 0.10 level.

Hannay (1976) in the second of the studies replicates this link for females only. She showed a link between high scores on the WAIS block design and matching stimuli more accurately in the left visual field for thirty right handed female subjects. The same effect was not demonstrated for thirty right handed male subjects.

Similarly to Hannay's negative finding for males, Davidoff (1977) was unable to demonstrate a link between right hemispheric superiority in tests of subjective brightness and a shape rotation test.

Another study that is relevant to this is Witelson's (1976, already reported, pp 51-52) where no link was demonstrated between degree of right hemispheric functioning and accuracy in a spatial task.

In summary I think it fair to say that this important implication of the explanation for sex differences has not been experimentally shown.

4. Dominance and Spatial Ability

Much attention has been paid in the literature concerned with laterality as an explanation for sex differences in spatial ability to the effect of dominance. Findings on the effect of handedness on spatial ability are by no means conclusive. Table 4 demonstrates some of these.

As the table demonstrates no consistency is observable either for both sexes or for sexes separately considered. Further more a cautionary note in assessing many studies is sounded by Heim & Watts (1976), page 355 in their introduction to their own study. 'It was felt, however, that some of the reported studies such as Levy's are unsatisfactory by virtue of paucity of numbers, extreme selectivity of subjects and unsuitability of psychometric measure ...'. They felt their own study avoided these pitfalls and indeed the large numbers involved (2165) and age range (school children aged nine to adult) would seem to bear this out. In general then differences are clearly not significant as between left and right handers and furthermore as Annett (1976) observes indices of dominance are extremely difficult to establish: 'the identification of signals, or left handers, in any region of the distribution is never absolute but subject to misses and false alarms'(p. 592). For these reasons I have not pursued this line of enquiry further.

In summary then the explanation under consideration for sex differences in spatial ability can only be conclusively accepted when (1) some further clarification is available as to the precise nature of the hemispheric 'packages' referred to by Maccoby and Jacklin and (2) when the link between high spatial ability and a high degree of lateralisation has been firmly demonstrated. I would like, however, to consider how the theory accommodates the five summary points on documented sex differences in spatial ability (pp. 20 - 21). Points 1 and 3 are clearly well accommodated. Adults whose lateralisation should be firmly established, would be expected, in terms of the theory, to show sex differences. Points 2 and 4 deal with children. Here the age by which lateralisation is regarded as being established is clearly

TABLE 4: EFFECT OF DOMINANCE ON SPATIAL ABILITY (TESTS EITHER SPATIAL OR 'QUASI' SPATIAL)

Lefthanders or mixed dominance significantly worse				Lefthanders or mixed dominance not worse			
Study	Sex	Test	LH or mixed	Study	Sex	Test	LH or mixed
Pizzamiglio (1974)	both	EFT	mixed	Pizzamiglio (1974)	both	RFT	mixed
McGee (1974)	females	standardised spatial tests	LH	McGee (1974)	males	standardised spatial tests	LH
Yen (1975)	males	"	LH	Yen (1975)	females	"	LH
				Newcombe et al. (1975)	both	WAIS (performance)	LH & mixed
Levy (1969)	both	WAIS block design	LH	McGlone & Davidson (1973)	both	PMA space	LH
				Heim & Watts (1976)	both	AH2/3 perceptual reasoning	LH

relevant. There is some controversy within the area. Some[1], Young and Ellis (1976) for example seeing little change after about five or six years, others, for example, Lennenberg (1967) putting it as late as thirteen. The last point is not at all well accommodated by the theory. All adults, irrespective of culture, should show sex differences if these are predicated in differential patterns of lateralisation for the two sexes. Table 3D summarises the position.

Biological Determinism: Theory 3: Sex Differences in Spatial Ability are Governed by a Recessive Gene

Vandenberg (1969) has suggested that spatial ability has a high level of heritability. This suggestion comes from twin-studies and while this is not an appropriate time to discuss the methodology of such studies, it should be mentioned that these studies are frequently open to criticism both on statistical and experimental grounds (see for example Kamin, 1977). However this suggestion together with the accepted sex differences in this ability has led to the proposal that spatial ability has a genetic linkage.

1. It will be also remembered that Witelson, for instance, sees the intersex differences in lateralisation present as early as six years of age.

TABLE 3D RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P. etc.	Laterality (m. bi-lat.)	(f. bi-lat)	Recessive Gene	Hormones
I Western Adults Sp. tests (m >)	**	**	**	Well accommodated		
II Children Sp. tests (m > after 13)	-	**	*	Depends on when lat- erality is regarded as being established		
III Western Adults F.I. and q-sp. tests (m > mostly)	*	**	**	Well accommodated		
IV Children F.I. and q-sp. tests (n.c.d.)	-	**	*	Depends on when lat- erality is regarded as being established		
V Cross-cultural F.I. and q-sp. tests (n.c.d.)	**	*	-	Not well accommodated		

KEY
F.I. field independence
sp. spatial
m/f bi-lat. males/females more bilateral
D.P. differential practice
q-sp. quasi-spatial
n.c.d. no consistent difference
m > males score higher
** well accommodated
* reasonably well accommodated
- not well accommodated

Five studies of spatial performance have found patterns of family correlations which are relevant to the hypothesis that a recessive sex-linked major gene contributes to high spatial ability and I shall discuss each of these in turn. In 1961 Stafford suggested that if a spatial ability trait were located on a gene in the X chromosone a certain pattern of family correlations would be apparent. 'For example, we would expect a zero correlation between fathers and their sons, but a significant one between fathers and their daughters, since the father passes his Y chromosone to his son, while his X chromosone, carrying the gene determining the trait, is passed to his daughter. Since the son's X chromosone comes from his mother the correlation between mothers and their sons should be significant and equal in magnitude to the one found between fathers and their daughters. Mothers and daughters would give a somewhat smaller positive correlation' (p. 428).

He gave a sample of 104 fathers and mothers and their 58 teenage sons or 70 teenage daughters the Identical Blocks test and obtained the correlations shown in Table 5. Following on this Hartlage (1970) gave the DAT space test to 25 families obtaining the correlations also shown in Table 5.

Another study by Corah in 1965 also explored family correlations on the EFT and CFT. This study was concerned with interpreting the results in terms of Witkin's theory of field independence but I shall refer to it here as it is often quoted in the literature in this area for example by Buffery and Gray in their discussion of genetic effects on spatial ability. In Corah's study 60 families were tested and once again the resulting correlations appear in Table 5. Finally in 1973 Bock and Kolakowski studied 167 families using a version of the Guilford Zimmerman test. Once again the correlations appear in Table 5.

TABLE 5: FAMILY CORRELATIONS ON SPATIAL ABILITY FROM FOUR STUDIES

Study	No. of fam.	FA-MO	FA-SON	FA-DAU	MO-SON	MO-DAU
Stafford	104	.03	.02	.31	.31	.14
Hartlage	25	-	.18	.34	.39	.25
Corah	60	.14	.18	.28	.31	.02
Bock & Kolakowski	167	.26	.15	.25	.20	.12

While I am unable to comment on the elaborate genetic statistical analyses in the last of these studies, in the first three studies there are none that have not been presented in Table 5.

Of the Stafford study, Guilford commented in a personal communication to me that 'Stafford's study should be repeated, using more reliable tests than he had' (letter dated 3rd December, 1974). Indeed a central criticism of the two first studies is that no statistical allowance at all was made for the validity of the test. The Stafford study however obeys the criteria laid down by Stafford (see above) very closely. The Hartlage study on a very small sample obeys this less well. Indeed there is no significant difference between the correlations between FA-SON and MO-DAU. In the Corah study again the match to Stafford's criteria is poor. For example the MO-DAU correlation is smaller than the FA-SON[1].

The Bock and Kolakowski analysis is far more complex and they conclude from their data that spatial ability has two specific determiners only one of which is sex linked. It is of interest however to note that the highest correlation they report is that between the parents.

1. In addition, as will be discussed in Chapter 4, it is possible to question the use of EFT and CEFT as measures of spatial ability.

They themselves make no reference to this beyond noting that 'the effect of assortative mating is small' (p. 9). In addition to showing that their data match a sex-linked determination for one component of spatial ability Bock and Kolakowski also showed that there was sexual dimorphism on scores of 727 students on the same test. That is the score distributions for the two sexes differed. I am unable to comment on the extremely complicated statistical treatment of this data and accept their interpretation that this fits in within their theoretical model for the sex-linked component of spatial ability, shown by their familial sample. However they conclude that only approximately 46% of the variance on these results is attributable to genetic variation.

Fairweather notes on these studies (p. 256) 'There is little doubt that high spatial performance is strongly influenced by a sex-linked major gene, but attribution of sex differences to such an influence is neither simple nor complete'. The fifth study in this area supports this conclusion. This was done by Yen (1975B). She tested 2508 American high-school children on four paper and pencil tests and examined sibling correlations and within-sex score distributions for the influence of a major sex-linked gene. These tests represented four supposed components of spatial ability[1] -two dimensional orientation and two dimensional visualization and three dimensional orientation and three dimensional visualization (henceforth to be referred to as 2D-SO, 2D-SV, 3D-SO and 3D-SV). Of these four components neither 2D-SO or 3D-SV fitted the statistical requirements for sex-linkage. For the other two tests, the gene frequencies were not consistent and Yen concluded that the sex-linked influence was most clear on the test of two dimensional visualization. In addition she performed a multiple component analysis on the tests and she extracted two principle components. The first of these she labelled a 'general spatial' factor and she showed that it too obeyed the statistical criteria for sex linkage.[2]

Like Fairweather and Bock and Kolakowski, Yen concluded that 'sex-linkage is not a complete explanation of the sex differences observed' (p. 297)

Finally in discussing the theory I shall examine how well it accomodates

1. In Chapter 4 I will define the factors spatial visualization and spatial orientation and discuss them in detail.
2. In Chapter 4 I will return to this topic and examine the possibility that, in the absence of any other than spatial tests in her factor analysis, interpretation of the first component may be open to debate.

the five summary points I derived from the studies of sex differences in spatial ability (pp. 20-21). As will be seen by reference to Table 3E these are well accomodated with the exception of the cross-cultural results. Point 1 the consistently superior performance in the West for adult males on standardised spatial tests is clearly accomodated and Point 3, their less consistent superiority in field independence and 'quasi' spatial tests can be understood in terms of these tests being less heavily loaded with the sex-linked spatial component. Point 2, the lack of sex differences on spatial tests in children below 13 years of age is less easy to explain unless it is assumed that (i) these tests are not loaded with the sex-linked component of spatial ability or (ii) as Bock and Kolakowski themselves postulated, this gene is 'testosterone limited in its expression' (p. 12). I shall return to this hormonal influence in the next section. A similar explanation could be postulated for the lack of consistency on children's scores on field independence and 'quasi' spatial tests.

Finally the cross-cultural results are not clearly understood in terms of this theory, although one possible explanation on the lines of Dawson may be offered. Dawson claims (see e.g. 1972A) that males

TABLE 3E RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P.etc.	Laterality (m. bi-lat)	(f. bi-lat)	Recessive Gene	Hormones
I Western Adults Sp. tests (m>)	**	**	**	**	Well accommodated	
II Children Sp. tests (m > after 13)	-	**	*	*	Not easily accommodated	
III Western Adults F.I. and q-sp. tests (m > mostly)	*	**	**	**	Well accomodated	
IV Children F.I. and q-sp. tests (n.c.d.)	-	**	*	*	Not easily accommodated	
V Cross-cultural F.I. and q-sp. tests (n.c.d.)	**	*	-	-	Not well accommodated	

KEY F.I. field independence sp. spatial m/f bi-lat. male/female more bilateral

D.P. differential practice q-sp. quasi-spatial n.c.d. no consistent difference m > males score higher

** well accommodated * reasonably well accommodated - not well accommodated

in developing countries may suffer through malnourishment, 'testicular feminisation'. Archer (1976) however points out that Dawson's theory is based on technically erroneous premises (see p. 77).

In summary it must be stressed that there does seem a clear indication of some sex-linked influence on scores of tests of spatial ability. Any account of the aetiology of sex differences in this areas must take this into account although it is unlikely to offer a complete explanation for these differences[1].

1. For example the results on the Turner girls (45, XO) and males suffering from the 47, XXY syndrome are not easily explicable in terms of this. For a full account of this see Theilgaard (1972) who concludes that (page 279) 'If Stafford's postulate - that spatial ability is transmitted by a recessive gene on the X-chromosome is correct, the distribution of this ability should be similar for males of normal chromosome constitution and for females with 45, XO. This seems not to be the case. The hereditary base is probably much more complicated and multifactorial. At present there are not sufficient data available to settle the question of the role played by biological vs. educational and socio-cultural factors in cognitive style' (my emphasis).

Biological Determinism: Theory 4: Hormonal Explanations of Sex Differences in Spatial Ability[1] (Broverman et al.)

Broverman et al. have offered an explanation for sex differences in spatial ability that derives from their more general theory about sex differences in all aspects of intellectual performance. I think their theory may be summarised in the following three propositions:

1. Intellectual performances may be dichotomised as follows. The first category is seen as referring to those performances that are dependent on simple, quick and accurate over-learned behaviour, involving fine co-ordination of small muscular movements and requiring little insight (p. 28). The second category embraces tasks which basically require the subject to separate certain stimulus attributes from the field in which they are embedded. These tasks are seen as 'involving extensive mediation of higher processes' (P 28) and involving insight as opposed to speed and accuracy for successful performance. Typical of the first category are clerical

1. For this section on biological theories I shall draw heavily on the critiques offered by Archer (1976) and Maccoby and Jacklin (1974) as my own experience in the pharmacological field is limited.

aptitude tests, digit span, verbal skills, and manual dexterity. Typical of the second category are the EFT, RFT, Koh's blocks, maze performance and spatial skills.

2. Women excel at the first category of tasks and males at the second.

3. The two classes of behaviour are affected in opposite ways by manipulations of the balance between the adrenergenic and cholinergenic central nervous system. The first set of tasks are seen as simple perceptuo-motor tasks and the second as inhibitory perceptual-restructuring tasks. Oestrogens facilitate activation by stimululating adrenergic mechanisms, and thus contribute to high performance at the first set of tasks whereas androgens are weaker in this respect and facilitate inhibition and thus high performance at the second set of tasks. Thus women excel at the first and men at the second.

I will discuss these propositions in turn. The first relates to their dichotomising of intellectual performance. Like Parlee (1972) I would take issue with Broverman's classifying verbal tasks such as reading as simple overlearned perceptuo-motor tasks that require minimal mediation of higher cognitive processes. Secondly Vernon's (1972) study showed that the rod-and-frame test shared little variance with tests such as Koh's blocks, and again with Parlee I would question whether one underlying factor could account for the wide range of tasks listed by Broverman et al. in the second category.

With respect to the second proposition, I have already reviewed results on field independence tests (e.g. RFT and EFT) and Koh's blocks and indeed verbal skills that would not support this proposition (see also Maccoby and Jacklin (1974) for verbal skills).

I am unable to comment on the third proposition. However Maccoby and Jacklin in their evaluation of the experimental work bearing on this cite a number of studies that show that men with highly 'masculine' characteristics and presumably therefore high levels of androgens tend to score poorly at spatial tasks (pp 123 - 125).

In general then I feel that this explanation of intersex differences in spatial ability is based on a theory that requires much further amplification and support before it can be accepted.

Relating the theory to my own five summary points on sex differences (p. 20 - 21) it will be seen from Table 3F that the theory could accommodate point one well (adult men superior at tests of spatial ability in the west) as these clearly lie in Broverman et al.'s second category of skills. Again the consistent trend for adult western males to be superior at tests of field independence and 'quasi' spatial tests (point 3) is clearly predicted by the theory. However the frequent negative results on for example EFT would be difficult to accommodate. With respect to the emergence of sex differences at the age of 13 years on standardised spatial tests the theory would predict this in terms of the low level of hormones present before puberty (point 2), and point 4, the inconsistency of intersex differences on children's scores at tests of field independence and 'quasi' spatial tests, would also be predicted by the theory, but only at ages before puberty. Finally the last point referring to lack of consistent sex differences in cross-cultural studies cannot be accommodated by the theory without reference to Dawson's 'testicular feminisation', to be discussed on page 77.

In summary then although the theory accommodates four out of five of the points relating to test data well, fundamental doubts remain about the validity of the theory.

TABLE 3F RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P. etc.	Laterality (m. bi-lat)	(f. bi-lat)	Recessive Gene	Hormones
I Western Adults Sp. tests (m >)	**	**	**	**	**	Well accommodated
II Children Sp. tests (m > after 13)	-	**	*	*	*	Well accommodated
III Western Adults F.I. and q-sp. tests (m > mostly)	*	**	**	**	**	Inconsistent results on EFT, RFT, not easily accommodated
IV Children F.I. and q-sp. tests (n.c.d.)	-	**	*	*	*	Inconsistent results on EFT, RFT after 13, not well accommodated
V Cross-cultural F.I. and q-sp. tests (n.c.d.)	**	*	-	-	-	Not well accommodated

KEY F. I. field independence sp. spatial m/f bi-lat. males/females more bi-lateral

D. P. differential practice q-sp. quasi-spatial n.c.d. no consistent difference m > males score higher

** well accommodated * reasonably well accommodated - not well accommodated

Biological Determinism: Theory Five: Hormonal Explanations of Sex Differences in Spatial Ability (Andrew, 1972. See also Archer, 1976)

I shall describe this theory very briefly indeed as it has received very little attention in the literature (e.g. Maccoby and Jacklin, 1974, make no mention of his work in their section on spatial ability and Fairweather, 1976, does not even cite his work as a reference). Briefly Andrew's position is that androgens such as testosterone increase 'persistence' which would favour performance on tests not requiring frequent switches of attention. It is my contention that spatial tests clearly do require frequent switches of attention; as an examination of the spatial tests included in this study such as the DAT (see p. 553) should demonstrate. Here the subject clearly is required to switch his attention from one to another of the possible solutions and then back to the stimulus object. Similar objections apply to 'quasi' spatial tests for example, it is difficult to regard a good sense of direction as primarily reliant on the ability not to shift attention. Furthermore as Archer shows, the theory has difficulty in accommodating the results on field independence. In order to accommodate these Andrews has to proose a complicated model whereby both females and high androgen males obtain low scores for different reasons. A further criticism of this theory is that much of the evidence cited in its support derives from non-human sources e.g. the increase in persistence of food-seeking behaviour of young male chicks with the injection of testosterone.

Clearly this theory will have to be considerably developed before it can account satisfactorily for inter-sex differences in spatial ability.

The Interactionist Perspective: Theory 1 (Dawson, 1972A and 1972B)

Like Witkin and Broverman et al., Dawson proposes two sets of cognitive behaviour which are seen as typical of the sexes. The 'female cognitive style' is that of high verbal ability and high field dependence and this is contrasted with the 'normal male cognitive style' (1972A, p. 22) which is typified by high numerical and spatial scores and high field independence.

This normal male cognitive style is seen as influenced primarily by 'neonatal androgen programming of the brain' (ibid) and partially by masculine socialisation processes.

With reference to the effect of androgens Dawson cites in support work done with rats which show decreases in spatial learning in a Tolman maze in male rats after the second of two oestrogen inplants. He failed however to show the contrary effect of an increase in performance for testosterone treated female rats. He also cites in support the low scores on tests of field independence of African males who suffered from gynecomastia[1] following malnourishment.

The first point to be discussed is the dichotomisation of cognitive styles. As has by now been shown repeatedly sex differences in verbal ability and in tests of field independence are by no means as consistent as Dawson implies. Further he also includes in the 'normal male cognitive style' high scores at tests that have not been associated in the literature with male superiority for example Koh's blocks (1972B) and three-dimensional pictorial perception which has been shown in the past to be clearly associated with practice (see for example Serpell, 1976).

1. Gynecomastia involves the growth of the mammary gland in males and is often accompanied by considerable atrophy of the testicles.

With respect to the effect of androgens Archer writes in this regard (1976, p. 244) 'In formulating this theory, Dawson must have misunderstood, or been unaware of, two important aspects of the evidence on early sex differentiation obtained from animal and human studies. First, in suggesting that sex hormones present after weaning can affect later behaviour, he ignores evidence that it is during later prenatal and early neonatal life that such long term hormonal influences have been found.... Secondly, in suggesting that oestrogen present early in life can typically produce female behaviour in the adult, he ignores the abundant evidence that the crucial factor for female differentiation is the absence of sex hormones (both male and female) early in life'.

It should also be noted that it is by no means surprising to find lowered test scores on any variety of tests in a sample of adults who have suffered malnourishment.

With respect to his contention about socialisation practices, Dawson's support for this is drawn from his own studies (1967A, 1967B). Thus the Eskimo are seen as high in field independence due to both their social organisation and to the ecological demands of their environment for a high degree of spatial skill, for example their ability to draw highly accurate three-dimensional maps in the snow.

In summary then two prongs of Dawson's account of sex differences are open to criticism - that it is possible to thus dichotomise cognitive styles meaningfully for the sexes and his account of the influence of sex hormones. The third prong that socialisation practices and ecological demands affect spatial skills is supported by cross-cultural studies.

In view of the fundamental criticisms that can be made of this theory, particularly with respect to Dawson's interpretation of his own data on hormonal influences, I will not relate this explanation of sex differences in spatial ability to my five summary points.

The Interactionist Perspective: Theory II (McGuiness, 1976)

In a review article on sex differences in perception and cognition, McGuiness proposes an interactionist perspective to account for various observed sex differences in abilities. Her account may be regarded as interactionist as she bases it on an early physiological sex difference which pre-disposes to differing interactional styles with the environment both with respect to objects and with respect to people. Before describing her approach in somewhat more detail, I should like to point out that no aetiology is suggested for this early physiological sex difference that she notes as characteristic of infants. In this respect then, her interpretation is descriptive rather than explanatory and thus differs from the other theories described.

The early difference she notes is in terms of the salient sensory modality: that boys are more sensitive to visual signals and stimuli and girls to auditory. This initial difference has wide ranging implications. Taking girls first - auditory sensitivity is seen as predisposing to an emotional reaction to intensity differences in speech and thus a greater reliance on communication with persons and a greater tendency to scan faces for verbal communications. Boys on the other hand because of their visual sensitivity respond earlier and with more intensity to objects in the environment.

She continues to speculate that early sensitivity differences may also produce 'subtle differences in looking behaviour, involving eye movements' (p. 143). Girls may scan their environment with a 'greater degree of visual axis' and boys with 'more vergence'. This may lead to a basic perceptual scanning difference in visual style with females searching 'pictorially' while males search 'spatially', that is girls look at a broader field with less depth and boys at a narrower field with more depth. In this way she accounts for differences in field independence/field dependence between the sexes.

Ultimately she considers that because males have a 'predominant characteristic' of 'exploration, internal and external structuring of non-social input' then this may lead to a more re-structuring and organising mode of thought. Whereas 'women whose approach is more communicative and whose interest is more social, would excel at analysing intent' (all quotations p. 146). Presumably this also is seen as accounting for sex differences in tests that require re-structuring and organising, like tests of spatial ability.

Looking critically at this interpretation, I note that Maccoby and Jacklin (1974) in reviewing differences in perception in children and infants conclude that (p. 38) 'The view that one sex is oriented more towards auditory stimuli and the other to visual cannot be supported by existing evidence' (p. 38).

It seemed then, that although the approach is attractive, this interpretation is too tentative and too speculative at this stage to be used as an explanation of observed sex differences on tests of spatial ability.

McGuiness' perspective concludes this section on theories posited to explain sex differences in spatial ability. Referring briefly to the summary table (3G) it will be seen that no approach is capable of accommodating all the points satisfactorily. In the last chapter of this study, I will return to the table and ask whether, if the points are reinterpreted in the light of the discussion of my own results, any perspective is then able to accommodate all the points satisfactorily or whether an interactionist approach combining two or more perspectives is able to do so in a more comprehensive manner.

Discussion

In these first two chapters, I have treated certain fundamental issues in a very cursory manner. I have done so for two reasons. In the first case most of the studies summarised and theories presented did not themselves examine the issues. Secondly I would prefer to treat them, in depth, within the context of my own results. The issues

TABLE 3G RELATING STUDIES ON SEX DIFFERENCES IN SPATIAL ABILITY TO THEORETICAL EXPLANATIONS FOR THE OBSERVED DIFFERENCES

	Social Conditioning		THEORIES	Biological Determinism		
FINDINGS	F.I.	D.P. etc.	Laterality (m. bi-lat.)	(f. bi-lat.)	Recessive Gene	Hormones
I Western Adults Sp. tests (m >)	**	**	**	**	**	**
II Children Sp. tests (m > after 13)	-	**	*	*	*	**
III Western Adults F.I. and q-sp. tests (m > mostly)	*	**	**	**	**	*
IV Children F.I. and q-sp. tests (n.c.d.)	-	**	*	*	*	*
V Cross-cultural F.I. and q-sp. tests (n.c.d.)	**	*	-	-	-	-

KEY F.I. field independence; sp. spatial; m/f bi-lat. males/females more bi-lateral

D.P. differential practice; q-sp. quasi-spatial; m > males score higher; n.c.d. no consistent difference

** well accommodated; * reasonably well accommodated; - not well accommodated

I refer to are:

(a) What precisely is meant by spatial ability? Is this ability unifactorial, bifactorial or indeed multifactorial?

(b) To what extent are the tests referred to valid measures of spatial ability or spatial abilities?

(c) If a test of spatial ability is a valid measure of the factor or factors for male subjects, is it equally so for females? and *vice versa*?

I will present an overview of these issues, in the context both of my own results and of the perspectives presented in the two final chapters.

CHAPTER THREE: THE METHODOLOGY OF THE TWO PROJECTS

Introductory Note

I noted in Chapter One, that although there seems to be a general concensus that sex differences, in favour of males, are shown on tests of spatial ability, there is little agreement as to the age of emergence of these differences. Maccoby and Jacklin (1974) and Fairweather (1976) see these as emerging at puberty but Dawson et al. (1974) and Buffery and Gray (1972) claim that these are seen at earlier ages. As I have already stated, the evidence available would appear to support the first viewpoint, but I have found the dearth of developmental studies, which could substantiate either viewpoint as correct, rather surprising[1]. With this in mind, one of the chief aims of the present study was to document developmental trends in sex differences in spatial ability. I realise that ideally this should have been undertaken

1. I was unable to find a single developmental study in this area until shortly before I commenced writing up my own results when I found reference to a Ph. D. Thesis in which children of four age groups were tested on two rotational spatial tests. This was done by Karnovsky in 1974 and I have already summarised her results on p p. 12 - 13 . It will be seen that they parallel my own.

as part of a longitudinal design, but within the time scale of submission for a higher degree, I have had to undertake a cross-sectional study.

The study was divided into projects. The first dealt with the age groups seven to eleven years and the second twelve to sixteen plus. Some of the twelve year olds of the second project had been included in the eleven year old age groups of the first and to this small extent supply a longitudinal element to the overall study. I will treat the two projects together in the next section where I describe my aims. Subsequently, within this chapter, each project will be described in detail separately. However for the documentation of the results the projects will again be treated together in view of their common aims (Chapters 4 - 8).

Aims of the Two Projects

(a) Establishing sex differences. In the first instance I wanted to see if these existed over a wide range of ages and for a variety of tasks. The results pertaining to this aim will be found in Chapter 5.

(b) Investigating the intercorrelations between different spatial and 'quasi' spatial tests. With reference to the first project, with younger children, I wanted to investigate the extent to which tests which had been documented as displaying sex differences in spatial ability, intercorrelated with each other. With reference to the second, I wanted to investigate the extent to which the subtests of a standard spatial test intercorrelated, These results are documented in Chapter 4.

(c) Investigating the 'g' loading of spatial tests. Few investigators of sex differences have considered whether any of the variance on spatial and 'quasi' spatial tests is due to an underlying educational or reasoning factor[1]. One of the aims of this study was to investigate to what extent spatial tests, 'quasi' spatial tests and tests of field independence were loaded with 'g'. The results of this analysis are reported in Chapter 4.

(d) Developmental trends. As mentioned in the introductory note to this chapter a major aim of this study was to attempt to document the age of emergence of sex differences in spatial

1. A notable and early exception to this is McFarlane Smith (1948).

ability. The results pertaining to this are reported in Chapter 6.

(e) Motivational factors affecting sex differences in spatial ability. In accordance with the hypotheses I outlined in pp 34-36 with respect to differential practice and expectation effects, I wanted to consider the effect of past experience, vocational aspirations, interests and sex of experimenter on sex differences in spatial ability. These results are reported in Chapter 7.

(f) The effect of coaching. I wanted to see if coaching increased the scores on a standard spatial test relative to a control group. This was only done in the second project. The results are reported in Chapters 5 and 7.

(g) Cognitive style. Finally, and with particular reference to the work of Witkin and Keogh (1971), I wanted to see if differences on tests of spatial ability could be ascribed to differences in this. The results relevant to this aim are discussed in Chapter 9.

Project One: The Primary School Sample

This project was chiefly concerned with repeating those studies which had reported sex differences in favour of boys on 'quasi' spatial tests and tests of field independence, in the age range seven to eleven years[1]. Inspection of the literature suggested that this male superiority was confined to relatively few tests:

(i) Tests of field independence. Only two studies showed sex differences in favour of boys on this for this age group. The first by Witkin et al. (1967) showed male superiority on RFT for 47 subjects aged eight years, but for 51 subjects aged eight and ten to thirteen years, no sex differences were found on this test. However a large sample of 515 subjects aged eight years to twenty one years showed sex differences on both EFT and RFT. This data however was not partitioned for age. The second study by Keogh and Ryan (1971) showed sex differences in favour of males on RFT for 44 subjects aged seven years.

(ii) Mazes. Fairweather and Butterworth (1977) and Wilson (1975) both showed sex differences in favour of boys with young children. In the first study the mean age was four and a half years and 144 children were used. Boys scored a mean of 10.46, s.d. 2.78, and girls a mean of 8.92, s.d. 2.49 ($p \leq 0.001$). In the second study 142

1. It will be recalled that no studies had been reported using standardised spatial tests for this age group.

pairs of twins were tested at four, five and six years. However in this study significant differences are only reported at six years and the actual figures are not given. Both studies used the maze subtest of the WPPSI. In addition other studies suggested sex differences on mazes at other ages, e.g. Davies (1965) with 540 adults in the age range 20 years to 70 plus, although a significant difference only occurred in the range 20 to 50 plus.

(iii) Tests of pattern walking. Keogh's work with this test has received much attention, although no other investigators have replicated her work. In the first study reported (1971) 135 children aged 8 to 9 years copied patterns by drawing and by walking in an extended spatial field under three conditions; no defined reference points, reference points and reference points plus tracking cues. No significant sex differences were shown in the drawing task, but boys were significantly better in reproducing patterns in two of three walking conditions. Keogh interpreted this in terms of a sex difference in perceptual style. I shall return to the details of this study when I discuss my own replication and refer to her interpretation of her results in Chapter 5. In the second study with Ryan (1971) Keogh also obtained a male pattern walking superiority with 44 subjects aged seven years.

(iv) Tests of location of place and location of compass points. In the only substantiation I have been able to find of Hutt's (1975B, p. 92) claim that males have a better sense of direction, Lord (1941), used 173 boys and 144 girls, mean age 9.1 years (range from grade V to grade VII). Sex differences were reported in ability to point out locations 'the boys were able to point out more locations than the girls but when accuracy of responses were compared there was no significant difference' (p. 492). Girls were however significantly worse at pointing out compass direction.

Project One was concerned with administering these four types of test to see if sex differences in favour of males obtained. Also, one more test of a spatial nature was included in the battery. This was a specially designed test of visualization.

Two sub-tests of the WISC were also given in order to obtain an estimate of 'g' (similarities and picture completion) and the coding subtest of the WISC was also included. I chose the latter two of those three, to give an estimate of 'g' on the advice of an experienced educational psychologist (Mr Henry Donaldson, Senior Lecturer in Psychology, Moray House College of Education) who regarded these as the most reliable measure of overall ability within the time scale of the battery. The coding sub-test was administered, as this is consistently reported as yielding superior scores for girls, and I wanted to see if my own sample was typical in this respect. The results on the coding sub-test will be reported in Chapter 5, the chapter dealing with sex differences but will not be included in the analyses of correlations or factor analyses as it is regarded as not contributing on the theoretical model employed, Vernon's hierarchical model of human abilities (see Chapter 4 for a full exposition of this) to either 'g' or a spatial factor.

All the children were asked to identify their right hand. This was done twice, once at the beginning and once at the end of the test session. In order to be classified as doing so correctly, children had to be right on both occasions. This was done in order to see if this ability affected scores on any of the quasi-spatial tests.

The children were further also asked questions about the degree to which they were allowed out on their own in order to see if this variable affected their scores on the location tests.

Finally the class teachers were also seen in order to obtain information about the children's interests and their ability at mathematics, art and physical education, all of which have been cited as affecting spatial ability (Karnovsky,1974; Vernon,1972 and Mayo and Bell,1972).

140 children were tested in five groups of 28. Equal numbers of boys and girls were tested within each group. Within each age group half the boys were tested by a male experimenter and half by a female. Similarily half the girls in each group were tested by a male and half by a female. This was done in order to check for sex of experimenter effects which have been frequently reported for young children of the primary school age group (see e.g. Bittner and Schindeling,1968 and Brekke and Williams,1973). Two male research assistants[1] and one female research assistant were used. None of the research assistants were told of the nature of the study - that the chief variable being considered was sex of subject.

1. Two male research assistants were used as one withdrew after testing fourteen children in Primary 3 (7 boys and 7 girls).

The experimental design can be summarised as follows:

Age level (5) X sex of subject X sex of experimenter X tests:

EFT

Mazes

Pattern drawing and walking[1]

Compass point location

Place location

Test of visualization

Picture completion

Similarities

Coding

Questionnaire data.

Project One: The Subjects

The children were drawn from a state primary school. I used two criteria in choosing the school. Firstly I wanted to be sure that

1. Pattern walking was only administered to Primary 4. This was because recording and scoring this was extremely time consuming and complicated. Primary 4 was selected as closest in age to Keogh's bigger sample. Both Primary 3 and 4 did Keogh's drawings.

the children would be highly motivated to co-operate in the test situation and so I selected a school which was known to have an academic bias and few behaviour problems. Secondly I was interested in the vocational aspirations of the older children and particularly in career choices like engineering, architecture and design for both sexes. Therefore I needed to have a sample with a middle class bias in order to obtain this.

The school is in a leafy Edinburgh suburb, which retains a strong sense of identity, perhaps due to the ancient village around which it clusters, and in the centre of which the school itself is situated. Moving around the Victorian building the overwhelming sensation is of an ordered and structured activity. Although the class teachers retain a fair amount of independence in the running of their classes, it is clear that the middle aged male head teacher is firmly in control.

Children were selected within the school as follows: for each of the five years from Primary 3 to Primary 7, one class was selected. As the school is unstreamed, the sole criterion used was the number on the role - the class having a role number closest to 28 being selected[1]

1. N's of 28 were chosen for each age group as class sizes ranged

in each case. In three of the years, numbers exceeded 28, and in these classes all children were tested and the responses of the requisite number randomly chosen. In the case of the one class with 27 on the role, three girls[1] were drawn randomly drawn from a parallel class and one of these was included in the sample. All three research assistants reported that all the children were most interested and keen to co-operate and none appeared shy or timid.

TABLE 6: PROJECT ONE: AGE OF SUBJECTS

Year	Boys		Girls	
	mean	s.d.	mean	s.d.
P 3	7.69	0.28	7.55	0.25
P 4	8.76	0.28	8.65	0.42
P 5	10.09	0.15	10.24	0.29
P 6	11.00	0.20	11.01	0.19
P 7	11.77	0.35	11.57	0.46

1. Two extra girls were tested as it was felt that withdrawing just one would result in that girl feeling she had been drawn for some particular reason thus possibly affecting her response to the situation.

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from 25 to 31 and the N had to be multiple of 4 in order to satisfy the experimental design.

Table 6 gives the mean and standard deviations of the ages for each year and each sex.

Project One: Tests Used

In this section I shall describe the tests used; scoring will be described in the next sub-section.

'Quasi' Spatial Tests

The embedded figure test. The test I used was an expanded version of the one I had used in Zambia (1970, 1972). The 22 stimulus figures and the two demonstration figures are to be found in Appendix VIII. I did not use the CEFT (Children's Embedded Figure Test) because the scoring procedure for this test involves removing the simple figure from view while the complex figure is being inspected for solution, (Witkin et al., 1971). It seemed to me that this procedure involves the use of short term memory in a way that no other standard spatial test does. Furthermore the child is given a verbal label for the simple shape, for example, 'tent' or 'house' and it would seem from Maccoby and Jacklin's review of this literature on sex differences in memory that such a procedure would favour girls (1974, pp 57 - 60). This could conceivably account for the inconsistent differences shown on this test (CEFT). I did not use the RFT as a measure of field independence as the only version available was an unstandardised portable one and I had strong reservations about the reliability of this (see pp 28-31).

The maze test. The standard version of the Porteous maze for children was used. I did not use the WISC maze test subtest as there are only five mazes for the age group I was testing (MAZE).

Keogh tests (Tests of pattern walking). I replicated the nine patterns used by Keogh and described in her 1971 study. In addition I used nine analagous 'meaningful' items, because I was interested in testing whether there would be an interaction between the degree of abstraction of the shapes and sex of subject. The 18 shapes can be seen in Appendix VIII. It will be seen that each Keogh item is related in overall complexity and shape to the similarly numbered 'meaningful' item. The complex procedure used for this test will be described in the next subsection. (KEOGH and MKEOGH).

Tests of location of place and compass directions. Children were required to point out five places in the neighbourhood of the school.

(These places had been determined, in consultation with the head teacher). They were also required to point out the four cardinal compass points as well as South West. A specially designed apparatus was used for this which will be described in the next sub-section (COMPLACE and COMPDIRE).

Test of Visualization. In the next chapter I will discuss definitions of spatial visualization as distinct from spatial orientation, in greater detail. However, at this stage I will differentiate between them briefly.

Spatial orientation has been described by French (see Yen, 1975 B.) 'perception of the position and configuration of objects in space, perhaps best thought of as space with the observer himself as a reference point' (p. 282). In this battery there was no quasi-spatial test that satisfied this definition. Visualization is defined as follows: 'With visualization, on the other hand, the observer seems removed from the stimulus pattern in that he appears to manipulate and alter its image' (p.282). I attempted to test this by asking the children to look at a map (see Page 574) and without touching it, indicate whether they would turn left or right[1] at various decision points

1. Especially for the younger children research assistants ensured

(see Appendix II for the intersection points). This test will be referred to as MAP I.

WISC Subtest The three WISC subtests were administered according to Weschler (1965, 1971) and will be referred to as CODE, SIML and PICT.

Finally the questionnaire about children's mobility can be found on p 432 - 33 Appendix II, and will be referred to as WALK.

Project One; Procedure [1]

The children[2] were withdrawn from the lessons and seen individually in a room set aside for testing. The research assistant then proceeded as instructed in Appendix II (p. 424). It will be seen that all the tests were administered at this session except for Pattern

1. The entire test battery was piloted on four children by each of the three experimenters. The Keogh walking procedure was piloted on six children by both experimenters concerned.
2. The parents of the children had all received a letter about the project (Appendix I).

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that the child was using the verbal label 'right/left' correctly by asking 'which side of your body would you turn?'.

Walking for Primary Four. Appendix II describes all the procedures in detail except for the apparatus used in COMPLACE and COMPDIRE. For this the following apparatus was constructed. A steel circle (radius $3\frac{1}{2}$") was set into a square wooden frame ($7\frac{1}{2}$" x $9\frac{1}{2}$"). In the centre of the circle was a hole. A rotating pointer fitted on top of this. For each child a clean circular sheet of paper was inserted on the steel sheet and secured in position by means of a pin at the end of the rotating pointer. This apparatus was placed in a fixed position on a small table. The child sat in front of the table and moved the pointer in the direction it thought each of the locations/ compass directions lay. The angles of deviation from the correct direction was calculated from the marked sheets later and a mean score was calculated for each child for the five items of each test. These mean scores were then subtracted from 180 so as to bring the scores directionally in line with the other tests used (i.e. the better the performance, the higher the score).

For the Pattern drawing section of the Keogh test the same procedure was followed as used by Keogh. Subjects were asked to make pencil copies of nine designs on $8\frac{1}{2}$" x 11" white paper, one design per page. Patterns were shown in the order of presentation shown on pp 575 - 577

The last five more complex patterns are combinations of the first five simple patterns. Before beginning the test pattern each subject copied a circle as a practice design. Patterns were presented on 8" x 8" cards which were visible while the subject drew. There was no time limit. Scoring however was slightly different from the Keogh method. Keogh got her assistants to copy the child's drawing on to a separate sheet and this was scored as follows: 'all drawn and walked patterns were scored into four categories, from an 'extremely poor, unrecognisable copy' to an 'accurate copy' (p. 26). I presume that a copy was made in order to bring the scoring method in line with the scoring method she used for the walking patterns (see below). In my study the children's drawings were scored later by an assistant who was completely unaware of the objects of the study and who was unaware whether individual drawings were done by boys or by girls. He compared them to the standard and then used the following system:

4 = an accurate copy

3 = a reasonable copy

2 = a recognisable copy

1 = a poor, unrecognisable copy.

In addition, if the orientation was incorrect, the drawing was moved down a category for the first three categories.

The Keogh Walking test was administered some weeks later (between two and four weeks). The children were brought up in groups of four or five to Moray House College of Education. They were tested individually by both a female and a male experimenter. However for each child one or other experimenter took the leading role to partial out sex of experimenter effects according to the research design, which required half the children of each sex to be tested by a male and half by a female.

When Keogh did her study she used three walking conditions.

(a) Floor - here the children walked the design on the unmarked floor of the school cafeteria and no reference points were given. 'The child was asked to pretend that the floor was a large piece of paper and that he had sticky paint on the bottom of his shoes, thus, wherever he walked he would leave a mark, so he could draw a picture by walking' (p. 26).

(b) Mat - here the procedure was exactly the same as (a) except that 'the patterns were walked on a 9' x 9' plain linoleum mat. Reference points were not identified and the child could start the pattern from any point on the mat' (p. 26).

(c) Sand - the patterns were walked in a 9' x 9' sandbox which was raked after each trial so that footprints were visible when the child walked.

As in the drawing of patterns the investigators copied the child's track as he/she walked it. These copies were then scored according to the four point categorisation used in the drawing task. For sixty of the 153 subjects this record was made by two investigators and interscore reliabilities calculated. These ranged from .27 to .93.

In my own replication I only used one walking condition. This was similar to the 'sand' condition used by Keogh in which the child was able to see his or her tracks as the design was walked. I chose this because it showed the largest sex difference (boys 28.03 mean, s.d. 3.91, girls 24.10 mean, s.d. 4.10). I was uneasy about the procedure she used because it involved the scoring being done from a copy of the child's tracks rather than its actual track. However attempting to photograph a sand track was thought to be impractical and the following modification of the sand procedure was adopted. The child removed his or her shoes, donned very woolly socks, stepped into a basin of French chalk and then walked the pattern on a 9' x 9' blackboard.

The resulting track was then photographed using a wide angle lens and a fast film (HP 4 ASA 400-650). The track was then erased with a damp mop and the next item commenced. The detailed experimental procedure will be found in Appendix III, pp 438 - 439 and photographs of typical records in Appendix VIII, page 578. These filmed records were then scored by the assistant who had scored the drawing records, using the same categories. He used the negatives which were mounted on a glass panel with an extremely bright light underneath this.

Project One: Reservations

At the conclusion of any experimental study, the author or authors usually feel that were they to repeat the project, certain changes would be beneficial. I have three reservations about project one.

The first concerns the EFT. I would at this stage prefer to have included the CEFT as well as my own version of this. While I did consider doing this and rejected doing so in terms of the already lengthy battery I now think that the CEFT should have been included, as this would have yielded some useful data which would have afforded direct comparison with the 1967 study made by Witkin et al.

Secondly I would have preferred to have scored some of the Keogh designs twice. However the scoring procedure was so time consuming and the expense of paying a second rater so great, that I did not do this.

Thirdly, I myself helped administer the Keogh walking trials. This was unavoidable because the female research assistant withdrew on the day of the testing and I could not cancel the arrival of the children or arrange the use of a room at any other stage at Moray House, so that I was forced to step in myself at short notice. It had been a major premise of this study that I would not myself administer any tests to the subjects nor score any except objective measures, because I had felt that in my Zambian study I might have implicitly helped the girls more in comparison with the boys. However the Keogh walking test procedure that I used allows of little assistance or cues from the experimenter and I feel that my interaction was minimal. It is not possible to calculate the effect of my presence as even when the male experimenter was the chief experimenter, I was present.

Project Two: The Secondary School Sample

Whereas it could be said that the main aim of the first project was to look at sex differences on 'quasi' spatial tests in the context of their intercorrelations with each other, the main aim of the second project could be said to be the investigation of developmental trends in sex differences on a standard spatial test. As I mentioned at the beginning of this chapter, this is optimally done with a longitudinal design, so in using as I did a cross-sectional one, I made every effort to match the different years as closely as possible.

As with the first project, the test battery of spatial tests was accompanied by a measure of general intelligence (the part I of the AH4 test of general intelligence, Heim, 1970). The children were also asked about career choice and interest. While I felt that young children may be intimidated and confused by a group test situation, I had no such reservations about the older sample.

Another major aim of this project was to investigate the effect of coaching on performance at the spatial test used. I did not, however, in this experiment, investigate interaction with sex of experimenter, for two reasons. Firstly I feel this is less salient in the group situation than it is in the individual testing situation and furthermore all the subjects had teachers of both sexes, whereas the primary school sample had all only been taught by female teachers. Secondly preliminary analysis of the results of the first project had not revealed any significant interactional effects of this nature.

As a result of using classes rather than individual testing, numbers of boys and girls were not equal, neither were numbers within each group. The experimental design could be summarised as follows:

For developmental trends

Age level (5) x Sex of subject x Tests Standard spatial test

Place location

Map visualization

Test of 'g'

Questionnaire data

Coaching effects

Age level (2) x Sex of subject x Second administration of MHS -

(1) Experimental group after coaching

(2) Control group after

same interval as experimental group but with no coaching.

I conducted all the test sessions myself with the aid of a male research assistant. The coaching sessions were conducted by a second male research assistant - an experienced science teacher with a particular interest in spatial skills.

Project Two: The Subjects

The subjects for this project were drawn from the comprehensive school for which the primary school already used was a feeder. This school has a high and well-deserved reputation as a lively and exciting learning environment. In the first school my project had been approached with reluctance and little interest by the head teacher. Contact with the head and deputy head of the secondary school was much more satisfactory. At their suggestion, I spent some days, prior to the testing, in the school attending various lessons and various meetings of the staff.

As in all comprehensive schools, I observed a wide range of motivation in the pupils. Although all the teaching was good, it was quite clear that for a minority of pupils the school offered little of interest. Although there were no overt behaviour problems, I was aware that my task would not be easy. Because I had used a wide ability range for my first sample I intended to do the same for the second. The optimum sampling procedure therefore seemed to be by tutor group. These are of course unstreamed and as children enter the school in Form I they are randomly assigned to them. Thus in each age group tested there was a minority of children who were only too ready to find an excuse to introduce a little light relief into the test sessions. At no stage and with no classes did they succeed in destroying the generally co-operative environment, but I was always aware of an undercurrent which implied that these children in particular really saw no reason to be excessively acquiescent to the requests of a non-teacher who was asking them to do some work which they knew would affect them personally in no way at all. They were easily spotted as they entered the room as they invariably seated themselves at the back.

I do not wish to over-emphasise this aspect of the testing, which in fact proceeded very smoothly, but I do feel that this is an aspect of testing within the adolescent age group that is seldom discussed. Unless one works with very academically inclined pupils or unless one is in a position to impose sanctions, asking teenagers to do tasks which may be of little intrinsic interest is not a necessary guarantee of highly motivated performance.

It is for this reason that I decided to acquaint the children with the aims of the study. As Appendix IV shows (p. 441) the children were told that we were looking at sex differences. The children were naturally not told of the expected direction of these differences. In preliminary chatting with the classes, I discovered that none of the subjects had ever read anything in this area, and it was quite clear that any guesses they made were quite speculative and no consensus was apparent. It might be argued that it would have been better not to have indicated what the main aim of the study was. However I felt that although the children were on the whole co-operative and reasonably interested, motivation would have been fairly low without the competitive element I was able to engender by appealing to inter-sex rivalry. Also, in principle, I prefer to acquaint subjects with the aims of the study in which they are involved (see Armistead, 1974, for a cogent discussion of the ethical argments involved).

I should note that during the two coaching sessions (with 2A2 and

4A2)[1] I was particularly aware that two or three of the pupils present were paying little attention to the coaching. In each case, both boys and girls were concerned so that I do not think this should bias the results. The numbers and ages of the children tested appear in Table 7[2].

TABLE 7: PROJECT TWO: AGE OF SUBJECTS

Year	Boys			Girls			
	mean	s.d.	n	mean	s.d.	n	
1	12.64	0.38	14	12.37	0.43	13	
2.	13.84	0.42	24	13.88	0.53	29	
3	14.80	0.29	14	14.62	0.38	14	
4	15.81	0.38	24	15.86	0.31	27	
5	16.69	0.33	12	16.63	0.27	19	total = 190

1. 'A' refers to the house concerned - thus the two coaching groups were Addison House, years 2 and 4, sets 1. Sets 1 and 2 do not differ in any way - the year group within each house is split randomly into two.
2. Within the first year sample was a subsample of the Primary 7 group that I had tested the previous year at the Primary School (n = 22).

Project Two: Tests Used

The major decision in this project concerned which standardised spatial test was to be used. I firstly considered the DAT space relations test. This takes thirty minutes to administer and can be seen on pp 553 - 564 of this study. I had previously used it in my 1975 study. I felt its drawbacks lay in the monotony of the test items and I found in a pilot administration of the test with girls attending a private school and aged 16 to 17 that my suspicions were confirmed. They rapidly became bored with the task. I then considered the use of the two Guilford-Zimmerman spatial tests (to be seen in Appendix VIII, pp 537 - 553). However inspection of the test protocols deterred me from using them. I considered with respect to the spatial orientation test that the stimuli were more likely to be familiar to boys (steering a speed boat) and certainly related to a skill that far more boys than girls were likely to want to obtain. I found the spatial visualization test very poorly reproduced[1] and had further reservations in that neither of these two tests has two dimensional as well as three dimensional stimuli.

1. Bock and Kolakowski (1973) evidently had the same reservations as when they used this test; 'Photographs were used to improve the clarity and realism of the items (p. 6).

Eventually I decided to use the Moray House Space Test Advanced I, (Jones, 1951). This had the following advantages:

(i) It had been designed for children of secondary school age.

(ii) It was broken up into sections and thus monotony of presentation was avoided.

(iii) Sections 1 and 2 dealt with two dimensional stimuli and sections 3 to 5 with three dimensional.

(iv) Sections 1 and 3 were clearly tests of orientation and section 5 was clearly a test of visualization. Sections 2 and 4 combined both aspects of spatial ability.

The Moray House space test takes one hour to administer. This was felt to be too long a period in view of the other tests being administered, so the test was split in two with the kind permission of the Godfery Thomson Unit for Academic Assessment, University of Edinburgh, the holders of the test's copyright. The split was achieved by taking every second item in sections 1, 2, 3 and 5. In section 4, which consisted of two sub-sections, the first of these was included The test was administered according to its standardised instructions. Both the test and the instructions can be seen in Appendix VI, Booklet

II and Appendix IV, pages 440-446 respectively. I shall refer to the test and its subsections as MHS and MHS 1 to MHS 5. Two other quasi-spatial tests were used, both analagous to tests used in Project One. The first was a test of place location (COMPLACE 2). Here the subjects were required to point out five locations in the neighbourhood of the school which had been chosen in consultation with the deputy head teacher. This test can be seen on Appendix VI, page 14, Booklet II. The third spatial test was a test of visualization in the map reading situation; this can be found in Appendix VI, Booklet I, page 11, (MAP 2). Instructions for the administration of these tests can be found in Appendix IV.

The test of general intelligence used (AH4), Alice Heim 4, part II can be seen in Appendix VI, Booklet I. This was used in association with the standard instructions for the test which can be seen in Appendix IV.

Subjects also answered questions about their career choice (Appendix VI, Booklet I, page 1) and their interests (Appendix VI, Booklet I, page 12) as well as their level of enjoyment (or otherwise) of AH 4 (Appendix VI, Booklet I, page 9) and MHS (Appendix VI, Booklet II, page 13.

Project Two: Procedure

The subjects were tested, in tutor groups (approximately 25 in number) in a classroom which was reserved for the purpose. Two experimenters (one male and one female) were always present and every effort was made to make the subjects as interested in the procedure as possible. The first test given in each case was the AH 4. After this the subjects did the map reading test (MAP 2). During this test subjects were not permitted to touch their booklets but at every test session I noticed some subjects shifting their body orientation while remaining seated - a clear indication of the degree of visualization involved. Instructions for these tests are to be found in Appendix IV, page 440.

After doing these two tests, subjects filled in the questionnaire data and then a five minute break was taken before Booklet II containing MHS and COMPLACE 2 was started. Before commencing COMPLACE 2, all desks were set to the same compass direction and all were set to right angles with the walls of the rectangular classroom. Then all students aligned their test booklets using the guide lines supplied on them before commencing COMPLACE 2. Setting all the desks and booklets in the same orientation, enabled me to mark the responses to this test by computer. From the prescribed orientation, only one numbered direction was accurate for each item. This was scored as 3 if correct, while a response on either side was scored as 2 and a response two directional lines away on either side of the correct line was scored as 1. All other responses were scored as 0.

Detailed instruction concerning the administration of COMPLACE 2 and MAP 2 can be found in Appendix IV, page 440.

The above test procedure was used with years 1, 3 and 5. For years 2 and 4, the test session just described was followed on the second meeting. In the first the four groups concerned only did the MHS test. In each case the first session took place exactly two weeks before the second. For the two experimental groups the first administration of MHS was followed by 50 minutes of coaching in this test, using the guidelines set out in Appendix V, and models especially made for the occasion[1] (see photograph on Appendix VIII, page 579).

1. During this coaching session, subjects did not retain their test booklets, otherwise it could be argued that they had more familiarity with the actual stimuli than the control group.

TABLE 8: LOCATION OF RESULTS FOR THE TWO PROJECTS

Results	Chapter numbers
Intercorrelations of the tests	4
Factor loadings on the tests	4
Sex differences	5
Developmental trends in sex differences	6
Coaching and its effects	5, 7
The effect on sex differences of sex of experimenter, children's experience, ability to identify right hand, ability at arithmetic and physical education, stimulus type, interests, career choice	7
Summary of results	8

Project Two: Reservations

My major reservation of this project is that it was not piloted as a whole. However the tests were piloted individually with eight subjects and difficulties in comprehension removed. Time limits for the non-standard tests were also established. In fact, piloting would probably have made little difference, as no difficulties in administration were encountered.

In addition I would have preferred a longer coaching session, or at least one more. Furthermore I consider this should not have taken place directly following the test administration as it did. A separate session for coaching might have alleviated the boredom that, as I have mentioned, two or three subjects showed in both years concerned. However both these improvements were not possible in terms of the administration of the school.

When I processed my data, I realised that I had tested rather more girls than boys, 102 compared with 88. This was particularly noticeable in the fifth year. I had not been aware of this at the time because this group was tested in two sessions. I would have preferred more evenly distributed numbers.

Finally, I was aware that the first year sample differed from the other four age groups. The later age groups represented an unbiased sampling of the population of the school. The first year did not, because 22 of the 27 concerned came from one feeder school. This school is considered by the deputy head teacher of the secondary school to be more middle class in its intake than any of their feeder schools. Furthermore it has a higher academic reputation than the other feeder schools. It will be seen that this has biased the scores on the test of general intelligence. In the next chapter, Table 13 B (p 156) shows that on AH 4 mean scores of the first year exceed those of the second and third year and almost equal those of the fourth and fifth. However, as the numbers of the sexes were evenly balanced in the first year, this is not seen as affecting the major variable under review, sex of subject.

CHAPTER FOUR: THE THEORETICAL STATUS OF A 'SPATIAL' FACTOR OR FACTORS

Introductory Note

Definitions of spatial ability (or faculty) are hard to come by. Although it is a term that is commonly found in articles on education as well as in more specialised psychological texts, its definition remains elusive. Neither the Concise Oxford Dictionary (1976) nor Chambers Twentieth Century Dictionary (1974) lists the term. It is however to be found in the Oxford English Dictionary (1961), Vol. Sole - SZ where it appears under the word spatial:

> Spatial - of faculty or sense: apprehending or perceiving space or extension.

More specialised definitions are not available. Neither A Dictionary of Psychology (Drever, 1976) nor the Encyclopedia of Psychology (Eysenck et al, 1972) list the term and no definition was found in texts on intelligence such as Guilford, (1967), Vernon (1969) or Butcher (1970).

This lack of definition extends to the area of sex differences as well. For example, Hamburg in The Psychobiology of Sex Differences (1974) refers to male superiority on spatial tasks and spatial ability interchangeably, citing as examples of spatial tasks, mazes, copying geometric figures, Koh's blocks and tests of field independence[1] and not indeed referring to any studies using standard spatial tests. Implicitly I think, using the operational definition I myself used in Chapters One and Two - spatial ability is what tests, regarded as spatial, measure.

In the three references I have used by Hutt, who is a well-known contributor in the field, neither of the two 1975 sources define spatial skills or abilities. In the 1972 source males are cited as superior in 'spatial perception and organisation. Typically, with his more analytical attitude, the male is able to abstract or maintain a perceptual configuration without being duly disturbed by its context - an ability reflected in his superior performance on the Rod and Frame test and the Embedded Figures Test (Witkin et al., 1962)' (p. 106) [1].

Garei and Scheinfeld in their seminal review of sex differences report

1. Both Hutt and Hamburg seem unaware that tests of field independence do not show consistent sex differences (see e.g. Witkin et al., 1967, who failed to show any significant sex differences for a seven year longitudinal sample).

males to be better on 'tasks requiring the perception, judgement, and manipulation of spatial relationships' (1968, p 202).

In this study, I will attempt to define spatial skills rather more specifically. Before doing so, however, I would like to consider the nature of tests that are regarded as measuring these skills. I will commence by asking to what extent do these tests we have been considering measure other than spatial factors? (However we are to ultimately define 'spatial'). To what extent are the tests loaded with more general abilities? Does 'g' load on them? Can they be done by the use of symbolic logic that is not related to visual imagery? In summary, then, how much common variance do spatial, 'quasi' spatial tests and tests of field independence share and is this shared variance best labelled as 'spatial ability'?

In a recent study, with blind subjects, Marmor and Zaback (1976) asked whether mental rotation depends on visual imagery. They asked early blind (blind from birth), late blind (blinded at approximately 15 years of age) and blindfolded sighted subjects to make same/different judgements of pairs of tactile forms (see Figure I).

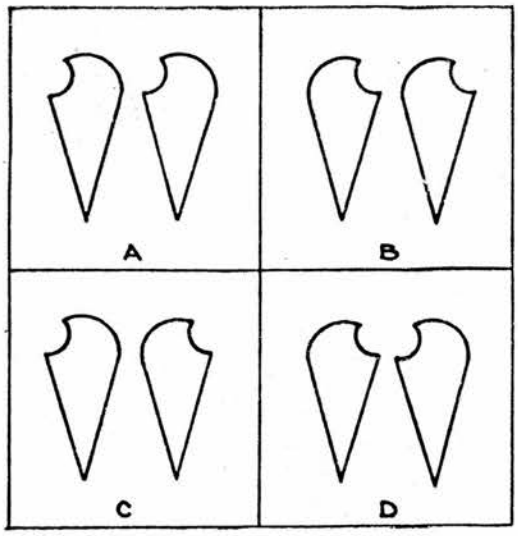

Figure I The Exhaustive Set of Stimulus Pairs: Same Pair (A), Same Pair (B), Different Pair (C) and Different Pair (D), from Marmour and Zaback, (1976, p. 517).

Their results were interpreted as showing that even early blind are able to mentally rotate objects though of course, they cannot use visual imagery to do so. They interpret their findings as suggesting that the early blind are able to 'organise the attributes of tactile forms into spatial representations that, like visual images, allow all attributes to be entertained simultaneously and that are specific enough to make possible the mirror image discrimination required in (their) investigation' (p. 520). I shall return to this experiment again in Chapter 9, however, I would note at this stage that this ability is close to that required in most tests of spatial orientation. For the present, however, I want to concentrate on the responses of certain subjects who used strategies other than mental rotation. Five subjects reported using a logical reversal strategy. 'One subject said that once it occurred to her that when the point was at the top, what she thought was left was right. Another reported that when the point was not facing him, a bit found on the left was really on the right. These subjects seems to have invented a verbal rule applicable to 150° (and possibly 120°) based on the realisation that when a stimulus is turned upside down, left and right become reversed' (p. 520).

Clearly the same technique is applicable to some spatial tests (a point explicitly acknowledged in the coaching instruction used in my own study, see Appendix V).

Vandenberg (1969) discusses this with reference to an Educational Testing Service (ETS) spatial test (see Figure 2). In this test the subject has to decide which of the eight figures on the right shows the same side as the model on the left and which ones are mirror images. 'While this task is usually done by sliding the figures

Figure 2 Example from ETS (S1) (Vandenberg, 1969, p. 279)

mentally around, it can be done by verbal reasoning or naming, such as saying 'is it 'b' or a 'd'?' or 'If the little knob is on top, is the larger bulge towards the right or the left?'' (p. 279).

The central point I shall make in this chapter is as follows; unless a battery of spatial tests is accompanied by a measure of 'g', and unless a factorial investigation is conducted, it is not satisfactory to assume that common variance on the spatial tests is due to a spatial factor or factors.

Before looking in detail at my own results in order to illustrate the point, I shall need to consider two theoretical models of the spatial factor or factors - (i) Vernon, and (ii) Yen.

Vernon's model of human abilities with particular reference to spatial ability

Intelligence and ability testing no longer enjoy the wholehearted acceptance that they did in 1961 when Vernon published the second edition of The Structure of Human Abilities. In this book, he devoted only one paragraph to a discussion of intelligence as a concept and at no stage at all did he appear to question either the theoretical base or the methodology of an exclusively psychometric approach to the subject. By 1969 when Intelligence and the Cultural Environment appeared the psychological climate had changed enormously. Two chapters of this book are devoted to theoretical problems associated with the conceptualisation of intelligence and other human abilities. A far more sophisticated treatment of intelligence is offered with its categorisation into three different meanings. The first is concerned with the innate potential of a human being and 'determines the mental growth of which he is capable' (Vernon, 1969, p. 9). This is referred to as Intelligence A[1]. The second refers to the level of performance displayed by the individual in his encounters with the world (Intelligence B). This is seen as deriving both from Intelligence A and the environment in which he has grown up. The third use of the word concerns intelligence as measured by intelligence tests (Intelligence

1. The dichotomising of Intelligence into A and B was, of course, first proposed by Hebb (1949, 1966).

C). This then, is an explicit acceptance by Vernon that in testing we only <u>sample</u> a subject's behaviour, and depending on the reliability and validity of the test and the extent to which the subject is motivated to perform well, gain some indication of Intelligence B.

In presenting Vernon's model, I wish to make it clear that my use of terms like general intelligence should only be interpreted at this last, tertiary level. When I use the term *g* I mean by this a common facility that appears to underlie many test performances. This facility will be affected in varying degrees, depending on the test situation, subject, administration and mode of scoring, by all of the following:

(a) Intelligence A[1].

(b) School Experience. This may affect performance on psychometric tests in at least two ways. Firstly, some schools explicitly teach cognitive strategies that optimise performance at reasoning tests. This is less common now that selection tests are seldom used. But it must have had a significant effect on test performance

1. Of course the effect of this is seen as varying from very influential (Jensen, 1969, Eysenck, 1971) to relatively unimportant (Jencks, 1975, Kamin, 1977).

when the Eleven Plus was in common use. Depending on the school attended, children might have had a very different exposure to say verbal reasoning items. Secondly, if a child has a high academic self concept (Hargreaves, 1975) then clearly he will approach psychometric tests at a motivational advantage compared with a child with a low academic self concept.

(c) Home background. Both Hess and Shipman (1963) in the U.S.A. and Bernstein (e.g. 1973) and his co-workers in this country have demonstrated that sub-cultural differences in cognitive modes and in the use of speech may disadvantage children from the lower working class.

(d) Attitude to the test situation. I have already discussed this in the last chapter. Very often there is no obvious advantage to be gained from working hard at a test and as a result the child may approach the situation in a very desultory manner. This is more likely to occur if the child's value system runs counter to the school's.

All these factors determine performance on tests other than those of *g* as well. Thus when I refer to a 'spatial factor' in discussing analyses of test batteries, it is with this discussion very much in mind. However, subject to these reservations, I will propose that such a factor will be shown to exist if:

(a) There is a group of performances that correlate highly with each other.

(b) These performances are relatively distinct from other performances (i.e. give low correlation with other performances).

(c) These performances occur on tests that appear to be concerned with spatial relationships[1].

To return to Vernon's model of human abilities - Figure 3 summarises it graphically. Vernon writes about this model as follows: '.... we can picture the mind as a kind of hierarchy or geneological tree, where the g - factor is the most prominent component in the sense that it accounts for the greatest proportion of differences in abilities (Fig. 3)

Over and above this, abilities tend to fall into major types - the

1. Vernon's definition of an ability reads 'It implies the existence of a group or category of performances which correlate highly with one another, and which are relatively distinct from (i.e. give low correlations with) other performances'(1961, p. 4). I have based my three points on this definition.

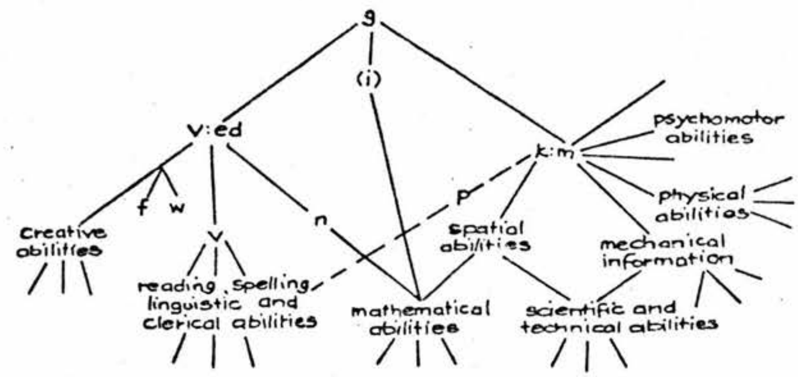

Figure 3 Diagram of the Main General and Group Factors underlying Tests relevant to Educational and Vocational Achievements (Vernon, 1969, p. 22)

verbal-educational (v:ed factor) and the spatial-perception-practical (k:m factor). Children, or adults, may differ appreciably in their performance in these two areas, although at the same time most people who are good at verbal tests will also score above average on spatial or mechanical tests, since both types of ability involve g.' (1969, p. 21).

If we accept this hierarchical model, then the salient question with respect to project one becomes: To what extent are the quasi spatial tests used (EFTS, MAZES, COMPLACE 1, COMPDIRE and MAP 1) measuring ability in addition to g? If they are loaded with a spatial factor, in addition to *g*, then using the points I noted characterising an ability, (p 129) they should display a high correlation that is distinct from their relation with the two estimates of *g* (the two WISC sub-tests).

With respect to project two, the salient question is: to what extent are the sub-tests of the spatial test used (MHS), its total and the two quasi spatial tests used (COMPLACE 2 and MAP 2) measuring spatial ability in addition to *g*? If they are loaded with a spatial factor, in addition to *g*, then their intercorrelations should be high and distinct from their correlation with the estimate of *g* used (AH 4).

In addition, factor analyses of the two test batteries should yield two distinct components.

Yen's model of spatial abilities

Yen (1975 A, 1975 B) identifies 'two major factors which describe the interrelationships of the spatial tests: spatial orientation and spatial visualization' (p. 281)[1]. Although Yen does not explicitly

1. (1975B) This derives from the factor analytic studies of Guilford and his associates (see Michael et al, 1957).

discuss the underlying model into which spatial visualization and orientation fit, it seems clear that in her conception of these factors Yen subsumes a model of intelligence based on the multifactorial concepts of Guilford who wrote in 1967 (p. 60) 'When the writer first faced the problem of organising the intellectual factors into a system, almost 40 (such) factors had been demonstrated (Guilford, 1956A, 1956B). Several facts based upon experience in factor analysis of intellectual tests in the United States had cast doubts upon the applicability of a hierarchical structure. Almost no one reported finding a *g* factor; in fact the tendency has been for each factor to be limited to a small number of tests in any analysis'.

I make this assumption about Yen's underlying model because in analysing (by means of a principal component analysis) the correlational matrix she obtained from her four paper-and-pencil spatial tests administered to 2058 school children[1], she labels the first factor unequivocally as a 'general spatial factor' (p. 291) and the second as (this) 'appears

1. I have already discussed this study of Yen's (pp 64 - 65) when referring to the theory that spatial ability is carried on a gene.

to be a contrast between orientation and visualization tasks'[1].

I will return to this assumption shortly. I would however first like to differentiate between the two spatial factors she discusses. I have already referred to this distinction in the previous chapter where I quoted the definition given by French 'The tests loading (on) spatial Orientation seem to involve perception of the position and configuration of objects in space, perhaps thought of as space with the observer himself as reference point. With Visualization, on the other hand, the observer seems removed from the stimulus pattern in that he appears to manipulate and alter its image' (Yen, 1975 B, p 282)

The reader will perhaps best appreciate this distinction by reading it in conjunction with examination of the tests produced by Guilford-Zimmerman as exemplifying the two factors (see Appendix VIII).

With reference to my own results, in project one only one test could perhaps be thought of as mainly testing one of these factors using

1. However, one of her four tests did not fit into this second factor, as Yen herself noted.

French's definition. This is MAP1 which was designed as a test of visualization. Thus results of this project cannot therefore be analysed with respect to this distinction. Project two, however, does have certain tests and sub-tests which can be thought of as relatively pure measures of these factors as defined by French:

spatial orientation - sections 1 and 3 of MHS and MAP 2

spatial visualization - section 5 of MHS and MAP 2 can be seen in Appendix VI, pp 450 - 475.

I will thus examine the correlation matrices and factor analyses with this model in mind.

Contrasting the two models

In contrasting the two models of Yen and Vernon, it should be first pointed out that Yen's is related to the theory that spatial ability is determined, in the main, by a gene. Vernon's theoretical treatment of abilities, including spatial ability, is more operational. He infers the existence of abilities from correlational data and makes no assumptions about their genetic determination. Indeed, his cross-cultural analyses implicitly acknowledge that abilities group themselves differently subject to differing environmental, cultural and ecological conditions. In the final chapter of this study I shall return to a discussion of the genetic theory in the light of my own results.

The second major contrast in the models lies in the underlying assumptions of the nature of human intelligence. Here I shall contrast Vernon's view with Yen's and Guilford's. I myself favour the former (Vernon's). In analysing the correlational matrices of her four paper-and-pencil spatial tests, Yen extracted a first factor which she labelled a 'general spatial factor', (see pages 64 - 65). In doing so I think she implicitly ignored the influence of any other than these postulated primary mental abilities - spatial orientation and spatial visualization.

As I have already pointed out, in my discussion of the difficulties inherent in testing adolescents, it seems to me that attitudinal and motivational factors must affect test performance. In addition to this aspect of testing, Yen also ignores a possible underlying general educational aptitude. This is of course to be expected, in view of her adherence to the Guilford model. However I think it leads her and her associates into some very dubious labelling of factors. In a study done with Hyde and Geiringer (Hyde et al., 1975), the three authors[1] gave 81 undergraduates of both sexes nine tests - RFT, EFT, vocabulary, mental arithmetic, work fluency test, alternate uses tests (listing uncommon uses for common objects), a spatial test (Stafford's Identical Blocks test), achievement motivation and a measure of femininity. The first factor extracted by a multiple component analysis was reported as follows (p. 301) 'Factor 1 appears to be a spatial factor'. It 'has high leadings for the spatial test[2], both field independence tests, and the mental arithmetic test. The only exception to this clean spatial factor (my emphasis) is that vocabulary also has a high loading on it'.

Surely this factor resembles a rather more general ability? It has a high loading on mental arithmetic (not normally thought of as having a big spatial component) and a comparatively high loading on vocabulary. Its labelling as a spatial factor seems to me a rather unusual interpretation of the data.

1. I shall refer to this study again in Chapter 9 .
2. Actual loadings for the tests referred to are - spatial ability, .74, EFT, .78, RFT, -.54 (the minus sign reflects the scoring procedure - high scores are associated with a worse performance than low scores), mental arithmetic, .66, vocabulary, .42).

In Yen's own study with 2508 school children and four paper-and-pencil tests, as I noted before, the first factor is unequivocally interpreted as a general spatial factor. It is open to speculation, at least, that had she included some measure other than spatial tests in her battery, the results would not have been as simple to interpret. Like the Hyde et al. study the spatial tests might have been shown to share some considerable variance with non-spatial tests. In her own study Yen then went on to perform some extremely sophisticated analyses of this factor. She showed that it produced sibling correlations in accord with a sex-linked inheritance of the factor. I am extremely dubious about this procedure, finding it difficult to assume, as she does, that her battery could have yielded a first component that was a pure measure of spatial ability and nothing else.

Therefore in considering my own results, I shall utilise the Vernon model, as distinct from the Yen-Guilford model, in looking for evidence of a spatial factor; referring throughout to the three criteria I listed on page 129 of this chapter. However I shall make use of the Yen distinction of two possible components of this factor. Results will thus be discussed as follows:

(1) Is there evidence of a spatial factor using Vernon's model

(a) in project one?

(b) in project two?

(2) Is there evidence that the spatial factor has two components - spatial orientation and spatial visualization using the French-Yen definitions of these components. For this only the results of project two will be relevant, as in project one, there was only one comparatively pure measure of the latter - MAP1, and no adequate measure of the former.

Finally I shall examine the distinction between two and three dimensional tests.

Reporting Results - 1. Is there evidence for a spatial factor?

Project One

In this section I want to examine closely the correlation matrix obtained for the whole sample[1], the correlation matrices obtained for each year group, the component analysis obtained for the whole sample and the residual correlation matrix for the whole sample, after the

1. Those analyses for the sexes considered separately will be treated in Chapter 5.

two WISC sub-tests had been partialled out. Before doing this, however, it might be of interest to report the overall means and standard deviations for the whole sample and the five year groups, on the measures to be considered. These are:

Quasi-spatial measures

The embedded figure test (EFT)

The maze test (MAZE)

Test of location of place (COMPLACE 1)

Test of location of direction (COMPDIRE)

Test of visualization (MAP 1)

Measures of *g*

Similarities (SIML)

Picture completion (PICT)

Table Nine summarises the mean and s.d.'s on these measures.

Table Nine shows that all tests tend to get easier as the subjects get older, although for two tests, EFT and MAZES the P5 means were marginally more than the P6, and in COMPLACE 1, P6 was marginally better than P7. This age progression does offer some validation for my own tests. In addition means and median were very close for most tests suggesting underlying normal distributions.

TABLE 9 : PROJECT ONE: MEANS AND S.D.'S OF SEVEN TESTS FOR TOTAL SAMPLE (n = 140) AND BY YEAR (n = 28)

TEST	TOTAL		P3		P4		P5		P6		P7	
	m.	s.d.	m.	s.d.	m.	s.d.	m.	s.d.	m.	s.d.	m.	s.d.
EFT	8.65	3.29	6.43	2.63	7.25	2.12	9.54	3.56	9.07	2.73	10.96	3.21
MAZE	11.77	2.12	10.17	2.19	11.30	1.84	12.98	1.47	12.02	2.14	12.39	1.81
COMPLACE 1	141.50	30.50	119.60	36.00	137.00	25.50	148.60	24.30	152.80	28.00	149.40	26.70
COMPDIRE	105.40	42.80	92.60	35.90	98.50	31.70	107.10	50.80	109.80	51.70	117.80	40.30
MAP 1	8.47	2.37	6.75	1.60	7.75	2.20	9.04	2.29	9.39	2.10	9.43	2.47
SIML	13.08	3.95	9.68	3.15	12.32	3.20	13.07	3.44	14.97	3.30	15.36	3.99
PICT	28.14	7.50	21.96	8.22	27.00	9.03	29.93	5.30	30.14	3.79	31.64	7.52

I will now discuss the intercorrelations of these tests in some detail, commencing with the matrix for the whole sample which is shown in Table 10.

Correlational Analyses

On first inspection of Table 10, it will be seen that there is a tendency for some of the quasi-spatial tests to correlate more highly with the WISC than they do with each other. For example MAZE and PICT (.4210) and EFT and PICT (.4366) intercorrelated more highly than do MAZE and EFT (.3133). In addition, it will be seen that the two directional tests do not intercorrelate more highly with each other (.3320) than they do with the WISC sub-tests, (COMPLACE 1, PICT = .3338 and COMPLACE 1, SIML = .3115).

Thus inspection of the correlation matrix does not indicate that the shared variance satisfies the criteria laid down on p 129 for the inference of an ability: (i) there is no clear indication of high intercorrelations for the quasi-spatial tests and (ii) these tests do not give relatively low correlations with other measures, in this case the two WISC sub-tests.

I examined the intercorrelations of the seven tests for each of the

TABLE 10: PROJECT ONE: INTERCORRELATION FOR TOTAL SAMPLE (n = 140) (Pearson's correlation co-efficients)

	MAZE	COMPLACE 1	COMPDIRE	MAP 1	SIML	PICT
EFT	.3133***	.3534***	.2397**	.4036***	.5508***	.4366***
MAZE		.1320	.1034	.3267***	.3371***	.4210***
COMPLACE 1			.3320***	.2737***	.3115***	.3338***
COMPDIRE				.2961***	.2499***	.1369*
MAP 1					.3531***	.3334***
SIML						.5532***
PICT						

Key *** = $p \leq 0.001$ ** = $p \leq 0.01$ * = $p \leq 0.05$

five years separately. In doing this I used Spearman's correlation coefficient[1] as the numbers were not large enough to warrant using Pearson's correlation coefficients. The results for each year can be found in Tables 10A to 10E.

Applying Vernon's criteria to Primary 3 (Table 10A) we can see that the intercorrelations between the quasi-spatial tests are not high except for COMPLACE with EFT (.4925) and MAZE with EFT (.4015). However as EFT correlates at approximately the same level with SIML (.5837) and PICT (.4671) and MAZE correlates reasonably highly with PICT (.3021) (i.e. the tests do not give relatively low correlation with other measures) the second criteria is not satisfied. There is thus not much evidence for a spatial factor for this year group.

Applying Vernon's criteria to Primary 4 (Table 10B) it will be seen that the intercorrelations between the quasi-spatial tests are

1. Spearman's correlation coefficients were used in preference to Kendall Rank Order Coefficients because (see Nie et al., 1975, p. 289) the former is 'a closer approximation to the product moment correlation when the data is more or less continuous' as was the case with the tests used in both projects.

TABLE 10A: PROJECT ONE: INTERCORRELATION OF SEVEN TESTS FOR PRIMARY THREE (n = 28) (Spearman's correlation Coefficients)

	MAZE	COMPLACE 1	COMPDIRE	MAP 1	SIML	PICT
EFT	.4015*	.4925**	.0314	-.2176	.5837***	.4671**
MAZE		-.0082	-.1340	-.0333	.3140*	.3021*
COMPLACE 1			-.0674	-.2543	.0665	.3875*
COMPDIRE				.0866	-.0726	-.2104
MAP 1					-.0916	-.1358
SIML						.3598*

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

TABLE 10B: PROJECT ONE: INTERCORRELATIONS FOR SEVEN TESTS FOR PRIMARY FOUR ($n = 28$) (Spearman's Correlation Coefficients)

	MAZE	COMPLACE 1	COMPDIRE	MAP 1	SIML	PICT
EFT	.0893	.2814	.1434	.1690	.3706*	.3936*
MAZE		.0949	-.2545	.2370	.1838	.2921
COMPLACE 1			.4750**	.1544	-.0006	.1869
COMPDIRE				.0374	-.0801	-.2215
MAP 1					.0945	.0483
SIML						.6350***

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

all insignificant except for that between COMPLACE 1 and COMPDIRE (.4750) thus giving no indication of a general spatial factor. However the correlation between COMPLACE and COMPDIRE is both relatively high and is distinct from correlations with other tests. It can be concluded then, that Primary 4 results indicate a common factor loading on COMPLACE 1 and COMPDIRE.

Applying Vernon's two criteria to the quasi-spatial intercorrelations of Primary 5 (Table 10C) it will be seen that these are not satisfied. Their intercorrelations are not high, nor are they distinct from the other tests.

As in Primary 4, COMPLACE 1 and COMPDIRE intercorrelate relatively highly (.5302) and because this correlation is relatively distinct from their correlations with other tests, it may be seen as indicating a common factor loading on these two tests.

MAP 1 correlates highly with COMPDIRE (.4028) and EFT (.5328) but as it also correlates at a relatively high level with PICT (.5068) and COMPDIRE correlates relatively highly with SIML (.4452) a factor, separate from *g*, is not indicated for these three tests (i.e. the

TABLE 10C: PROJECT ONE: INTERCORRELATIONS FOR SEVEN TESTS FOR PRIMARY FIVE ($n = 28$) (Spearman's

Correlation Coefficients

	MAZE	COMPLACE 1	COMPDIRE	MAP 1	SIML	PICT
EFT	-.2450	.2793	.2443	.5328**	.3091*	.2288
MAZE		-.2591	.2031	.2319	.0484	.0498
COMPLACE 1			.5302**	.1493	.0304	.1196
COMPDIRE				.4028*	.4452**	.1832
MAP 1					.1692	.5068**
SIML						.4333**

Key ** = $p \leq .01$ * = $p \leq .05$

second of Vernon's criteria is not satisfied).

As with the three other age groups discussed, there is no indication in Primary 6 (Table 10D) of a general spatial factor underlying the five quasi spatial tests. Their intercorrelations are not high, nor are they distinct from the other two tests.

Unlike the last two years discussed, there is no indication of a separate factor underlying COMPLACE 1 and COMPDIRE. Although the intercorrelation of these two tests is high (.4172) it is not distinct from the intercorrelation with the WISC sub-tests. For instance COMPLACE 1 and COMPDIRE both correlate equally highly with SIML (.4575, .4589) and COMPLACE 1 correlates significantly with PICT (.3889).

Inspection of the intercorrelations of the five quasi spatial tests for Primary 7 (Table 10E), shows that as observed with the four other age groups, there is no indication of a general spatial factor underlying them. In particular, EFT and MAZE tend to intercorrelate higher with the two WISC sub-tests than they do with the other quasi spatial tests (e.g. EFT, SIML, = .6221 whereas EFT, COMPLACE 1 = .1223) thus not satisfying the second of Vernon's criteria.

TABLE 10D: PROJECT ONE: INTERCORRELATIONS OF SEVEN TESTS FOR PRIMARY SIX (n = 28) (Spearman's Correlation Coefficient)

	MAZE	COMPLACE 1	COMPDIRE	MAP 1	SIML	PICT
EFT	-.0110	.0156	.0623	-.0734	.3107*	.0937
MAZE		-.0854	.0973	.0455	-.2131	-.1039
COMPLACE 1			.4172**	.1752	.4575**	.3889*
COMPDIRE				.1211	.4589**	.2185
MAP 1					.2346	-.2035
SIML						.2705

Key ** = $p \leq .01$ * = $p \leq .05$

TABLE 10E: PROJECT ONE: INTERCORRELATION OF SEVEN TESTS FOR PRIMARY SEVEN ($n = 28$) (Spearman's Correlation Coefficients)

	MAZE	COMPLACE 1	COMPDIRE	MAP 1	SIML	PICT
EFT	.5386**	.1223	.3619*	.3997*	.6221***	.4627**
MAZE		.0586	.2353	.1796	.5953***	.4342**
COMPLACE 1			.4311**	.3890*	.2039	.0712
COMPDIRE				.5414***	.2202	.2230
MAP 1					.2770	.3495*
SIML						.2880
PICT						

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

However as in Primary 4 and 5 there is an indication of a common factor underlying COMPDIRE and COMPLACE 1 (COMPDIRE, COMPLACE 1 = .4311) that is distinct from the other tests.

In summary then the correlation matrices for the total sample and the five age groups show little evidence of a spatial factor underlying the five quasi spatial tests. However in Primary 4, 5 and 7 there is some evidence for a common factor underlying COMPLACE 1 and COMPDIRE. For the moment I shall refer to this as a directional factor.

Factor Analyses

A factor analysis was performed on the correlation matrix for the total sample. The factor analytic method chosen was principal components. This choice was made for two reasons. Firstly it was the method used by both Vernon (1972) and Yen (1975B) when they were investigating their own test batteries for a spatial factor. Secondly this method imposes the least subjective criteria (see Nie et al., 1975, p. 470).

Table 11 lists the two factors extracted and their loadings on the seven tests. It will be seen that the factors confirm the conclusions drawn from the correlational data:

TABLE 11: PROJECT ONE: FACTOR ANALYSIS OF SEVEN TESTS: TOTAL SAMPLE (PRINCIPAL COMPONENTS)

	FACTOR 1	FACTOR 2
EFT	.752	-.034
MAZE	.571	-.486
COMPLACE 1	.579	.465
COMPDIRE	.459	.694
MAP 1	.652	.085
SIML	.770	-.141
PICT	.735	-.314
Variance	42.8%	15.2%

(i) Most of the common variance on this is due to a general factor (Factor 1), which may be labelled as <u>g</u>.

(ii) There is no indication of a spatial factor underlying the five quasi spatial tests.

(iii) A second factor appears to load on both directional tests, COMPLACE 1 and COMPDIRE. As this factor does not load appreciably on any other test (except negatively on MAZE and PICT) I shall label it tentatively as a directional factor and return to it in Chapter 5 when the separate factor analyses for the sexes are considered.

Partial Correlation Analysis

Another way for checking for a spatial factor is to partial out the contribution of the two WISC sub-tests and to examine the remaining partial correlation matrix. Table 12 presents this analysis. It will be seen that four out the ten coefficients are not significant even at the .05 level and one of the significant coefficients is significant only at the .05 level. This reinforces the two previous types of analyses.

TABLE 12: PROJECT ONE: PARTIAL CORRELATION MATRIX OF FIVE TESTS CONTROLLING FOR SIML AND PICT: TOTAL SAMPLE (n = 140) (PEARSON'S CORRELATION COEFFICIENTS)

	MAZE	COMPLACE 1	COMPDIRE	MAP 1
EFT	.1128	.1983**	.1290	.2424**
MAZE		-.0329	.0225	.1947**
COMPLACE 1			.2335***	.1537*
COMPDIRE				.2335**

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

Before discussing the implications of these results for the study as a whole, I will examine the analagous analyses for project two.

Reporting Results 1. Is there evidence for a spatial factor?

(B) Project Two

I shall present, as I did for project one, the correlation matrices, followed by the factor analysis and the residual correlation matrix after partialling out the test of general intelligence. Before doing this, however, I shall report the overall means and standard deviation for the measures to be considered.

Table 13A summarises the characteristics of the spatial tests used and Table 13B reports the means and s.d.'s of the two quasi spatial tests used (MAP 2 and COMPLACE 2) and the test of general intelligence (AH4)

Inspection of the means on the test of general intelligence (AH 4) reveals the biased nature of the first year sample. The same tendency is reflected in the scores on the other tests but to a lesser extent. It will be remembered that the first year sample included 22 of the

TABLE 13A: CHARACTERISTICS OF THE SPATIAL TESTS USED IN PROJECT TWO

TEST	VISUALIZATION	ORIENTATION	2-D	3-D	HIGHEST POSSIBLE SCORE
MS1	no	yes	yes		12
MS2	yes	yes	yes		24
MS3	no	yes		yes	7
MS4	yes	yes		yes	7
MS5	yes	no		yes	9
TOTMS	yes	yes	yes	yes	59

the children tested in project one and the school used for this project is regarded by the deputy head teacher of the secondary school as the most homogeneously middle class of the feeders to the secondary school. To the extent that the number of boys and girls in the longitudinal sample were equal (11 of each sex) and the number in the residual first year group in the secondary school nearly equal (3 boys and 2 girls), the main variable under investigation is not affected.

With respect to the other four years, there is a clear tendency on all the tests, for scores to improve with age.

TABLE 13B: PROJECT TWO: MEANS AND S.D.'S OF NINE TESTS FOR TOTAL SAMPLE (n = 190) AND BY YEAR

	TOTAL		YEAR 1 (n = 27)		YEAR 2 (n = 53)		YEAR 3 (n = 28)		YEAR 4 (n = 51)		YEAR 5 (n = 31)	
TESTS	m.	s.d.	m.	s.d.	m.	s.d.	m.	s.d.	m.	s.d.	m.	s.d.
MHS 1	7.04	3.83	5.07	4.01	6.81	3.60	6.75	3.92	7.72	3.49	8.26	4.01
MHS 2	16.57	5.65	14.07	5.91	15.89	6.01	14.86	5.65	18.31	4.57	18.58	5.14
MHS 3	4.14	1.83	3.74	1.66	4.28	1.86	3.75	1.94	4.18	1.84	4.52	1.79
MHS 4	4.33	2.28	3.78	2.49	3.94	2.82	4.57	2.15	4.51	2.27	4.93	2.14
MHS 5	3.05	2.48	2.04	1.99	2.83	2.29	2.61	2.27	3.41	2.79	4.10	2.50
TOTMHS	35.12	12.53	28.70	12.22	33.76	13.20	32.54	11.81	38.13	11.45	40.40	11.06
COMPLACE 2	8.78	1.95	9.00	2.43	8.40	1.92	9.21	1.83	8.69	1.95	9.00	1.61
MAP 2	9.95	3.32	9.48	3.30	8.11	3.21	9.79	3.19	10.45	3.53	11.61	2.54
AH 4	32.38	10.03	34.81	10.14	26.75	10.01	31.89	7.85	35.29	9.10	35.52	9.55

TABLE 14: PROJECT TWO: INTERCORRELATION OF NINE TESTS FOR TOTAL SAMPLE ($n = 190$) (PEARSON'S CORRELATION COEFFICIENTS)

	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
MS1	.6546***	.5426***	.3523***	.4300***	.8927***	.0413	.3692***	.3888***
MS2		.4940***	.4333***	.4854***	.8984***	.0497	.4263***	.4772***
MS3			.3458***	.3636***	.6697***	.0307	.2398***	.2980***
MS4				.3689***	.6087***	.1920**	.3741***	.1954**
MS5					.6687***	.0807	.3741***	.2609***
TOTMS						.0905	.4798***	.4651***
COMPLACE 2							.1636**	.0704
MAP 2								.3891***

Key *** = $p \leq .001$ ** = $p \leq .01$

Correlational Analyses

Table 14 shows the intercorrelations of the tests for the whole sample. Inspecting the correlation table for the total sample, it is clear that the coefficients of MS1 to MS5 with TOTMS are very high and this is of course to be expected, in view of the contributions each of the sub-tests make to this total. Using Vernon's criteria for the inference of an ability, it is clear that there is a high level of intercorrelation amongst the spatial sub-tests and MAP2. Thus the first criterion is satisfied. Applying the second criteria, it will be seen that this intercorrelation is not entirely distinct from intercorrelations with AH4. For instance MS2 correlates more highly with AH4 (.4772) than it does with either MAP2 (.4263) or MS4 (.4333). Furthermore, AH4 correlates almost as highly with TOTMHS as TOTMHS does with MAP2 (.4651, .4798).

The tentative conclusion would appear to be that there is some evidence for a spatial factor underlying the sub-tests of the MHS and MAP2 but there is also some shared variance on these tests with the test of general intelligence suggesting a *g* loading on these tests as well. With respect to COMPLACE 2, it is clear that this test correlates very poorly with the others and that its specificity is high. It is for this reason, as I shall discuss later, that two factor analyses were performed on the data. The first, a principal component analysis in accordance with the analysis for project one and the analyses of Vernon (1972) and Yen (1975B) and the second a classical factor analysis which is the more suitable approach if it is suspected that any of the tests' variances contain a high proportion of specific variance (Nie et al., 1975, pp 468-486).

Before presenting the factor analyses and residual correlation matrix after AH4 has been partialled out, I shall discuss the individual correlation analyses for the five age groups. It will be seen that they are very much in line with the total sample. For the comparitively small samples of years 1 and 3, Spearman's correlation coefficients were used while for the larger samples of years 2, 4 and 5, Pearson's correlation coefficients were used. It will be remembered that for years 2 and 4 the first administration of the Moray House test was always used in these analyses in order to standardise with the other three years.

Applying Vernon's two criteria to Year One (Table 14A) it is clear that while the spatial sub-tests do intercorrelate at a reasonably

TABLE 14A: PROJECT TWO: INTERCORRELATIONS OF NINE TESTS FOR YEAR ONE ($n = 27$) (SPEARMAN'S CORRELATION COEFFICIENTS)

	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
MS1	.4956**	.3717*	.1548	.0280	.6411***	.0090	.2497	.4673**
MS2		.5652***	.6308***	.4097*	.9277***	.0712	.2872	.5097**
MS3			.4395**	.3429*	.7011***	.1216	.0249	.1960
MS4				.4182*	.6493***	.2527	-.0347	.0917
MS5					.5244**	.1688	-.0696	-.0193
TOTMS						.1259	.2143	.4506**
COMPLACE 2							.2137	.1721
MAP 2								.3829*

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

high level in general, they also tend to share some common variance with AH4 (particularly in the case of MS2). Once again the specificity of COMPLACE 2 is apparent. Thus the data for the first year parallel the data for the total sample: firstly there are indications of both a *g* and a spatial component for the spatial tests and secondly COMPLACE 2 fails to correlate significantly with any of the other tests.

In the case of 22 children in the first year, their scores on the two projects can be intercorrelated. Table 14B shows the significant intercorrelations for the two projects using Spearman's correlation coefficients.

In Table 14B if the correlations of the five quasi spatial tests with (i) TOTMS and (ii) AH4 are compared, it will be seen that they correlate significantly more often with the latter than with the former, confirming the heavy loading found in the previous analyses on the five quasi spatial tests of project one. Some validation of MAP 1 and MAP 2 is offered by their significant intercorrelation despite the attenuation in the scores on MAP for the seventh year age group of the primary sample (see Table 9, p. 140).

TABLE 14B: SIGNIFICANT INTERCORRELATIONS OF THE SEVEN TESTS OF PROJECT ONE AND THE NINE TESTS OF PROJECT TWO FOR THE LONGITUDINAL SAMPLE ($n = 22$) (SPEARMAN'S CORRELATION COEFFICIENTS)

	MS1	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
EFT	.4271*	.5698**	-	.4561*	-	.5307**	.3984*	-	.4368*
MAZES	.3820*	.5285**	.4091*	.3963*	-	.5337**	.4214*	-	.5461**
COMPLACE	-	-	-	-	.4416*	-	-	-	-
COMPDIRE	.4110*	.3544*	-	-	-	-	.3967*	-	.4962**
MAP	.6513***	.4529*	-	-	-	.5293**	.3642*	.4720**	.6328***
SIML	-	.4241*	-	-	-	-	-	-	.6491***
PICT	.4082*	.4717*	-	-	-	.4432*	-	-	.6063***

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

COMPLACE 1 and COMPLACE 2, however, do not correlate significantly casting some doubt on the validity of this type of test.

In summary then the data from the small longitudinal sample confirm the conclusions drawn on pages 141 - 154 of this chapter; it would seem that the five quasi-spatial tests of project one have a high *g* component.

Table 14C reports the intercorrelations of the nine tests for the Second Year. Applying Vernon's criteria, the conclusions are similar to those for year one and the total sample; while the intercorrelations amongst the spatial tests are high, there is also shared variance with AH4 implying loading on the tests of a general factor as well as a spatial. As before, COMPLACE 2 tends not to correlate with other tests.

Table 14D reports the intercorrelations of the nine tests for the Third Year. Year 3 reveals similar trends to both the other two years discussed and the total sample; while the intercorrelations are high between the spatial tests, there is also some shared variance with AH4 implying both a spatial and a *g* component for these tests. Once

TABLE 14C: PROJECT TWO: INTERCORRELATIONS OF NINE TESTS FOR YEAR 2 (n = 53) (PEARSON'S CORRELATION COEFFICIENTS)

	MS 2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
MS1	.7359***	.6928***	.4527***	.4456***	.8610***	.1359	.4743***	.5389***
MS2		.6518***	.5058***	.4857***	.9195***	.1170	.3737**	.5818***
MS3			.4603***	.4657***	.7872***	.0271	.3753**	.4672***
MS4				.5383***	.6849***	.3642**	.4263***	.3073**
MS5					.6750***	.1462	.4552***	.4654***
TOTMS						.1825	.5051***	.6116***
COMPLACE 2							.3515**	.0171
MAP 2								.3680**

KEY *** = $p \leq .001$ ** = $p \leq .01$

TABLE 14 D: PROJECT TWO: INTERCORRELATIONS OF NINE TESTS FOR YEAR 3 (n = 28) (SPEARMAN'S CORRELATION COEFFICIENTS)

	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
MS1	.4120*	.4714**	.2795	.4459**	.7548***	.1651	.3128*	.3957*
MS2		.3786*	.4302**	.5200**	.8137***	.3009	.5359**	.3711*
MS3			.2493	.2304	.5435***	.3442*	.1431	.3980*
MS4				.2847	.6156***	.0080	.2802	.0658
MS5					.6974***	.2383	.4009*	.2359
TOTMS						.2267	.5844***	.4218**
COMPLACE 2							.0543	-.0118
MAP 2								.4632**

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

again, COMPLACE 2 correlates non-significantly with all the tests except one.

Table 14E reports the intercorrelations for Year 4. Year 4 appears to show very clear evidence for a spatial factor - the intercorrelations between the sub-tests of MHS are all significant and in most cases considerably higher than their intercorrelations with AH4. As with the three other years discussed, COMPLACE 2 does not correlate significantly with the other tests.

Table 14F shows the intercorrelations for Year 5. In Year 5, correlations appear to be of a lower order than they are in the other four years discussed. There are only four significant intercorrelations amongst the ten intercorrelations of the five spatial sub-tests. This compares with ten significant intercorrelations for years 2 and 4, eight for year 1 and six for year 3. Intercorrelations with AH4 are comparatively low as well. This might be interpreted as indicating less motivated performance for this, the oldest age group. However, inspection of Table 13B (p. 156) shows that mean scores for this year are higher on all tests than they are for the preceding years and this would not have been likely in the light of less motivated performance.

TABLE 14E: PROJECT TWO: INTERCORRELATIONS OF NINE TESTS FOR YEAR 4 (n = 51) (PEARSON'S CORRELATION COEFFICIENTS)

	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
MS1	.6283***	.5788***	.2939*	.5901***	.8496***	-.0041	.3834**	.3088*
MS2		.3858**	.2741*	.6103***	.8548***	.1098	.2971*	.3898**
MS3			.3808**	.3364**	.6477***	.0824	.3410**	.3096*
MS4				.3176**	.5351***	.0504	.3228**	.2806*
MS5					.7832***	.0492	.3625**	.2395*
TOTMS						.0538	.4229***	.4130***
COMPLACE 2							.0701	.1132
MAP 2								.2811*

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

TABLE 14F: PROJECT TWO: INTERCORRELATIONS OF NINE TESTS FOR YEAR 5 (n = 31) (PEARSON'S CORRELATION COEFFICIENTS)

	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2	AH4
MS1	.5888***	.4391***	.4141**	.2532	.8372***	-.0752	.3907*	.1147
MS2		.2242	.1879	-.0893	.6431***	-.1247	.5505***	.3056*
MS3			.1972	.3061*	.5923***	-.2598	.2607	.1929
MS4				.1884	.5366***	.4504**	.2075	.2137
MS5					.4804**	.0699	.4228**	.1052
TOTMS						-.0002	.5748**	.1890
COMPLACE 2							-.0528	-.1638
MAP 2								.2428

Key *** p = $\leq$ .001 ** = p $\leq$ .01 * = p $\leq$ .05

In addition, analysis of the answer to the two questions 'how much have you enjoyed this test?' reveals no differences in response for years 4 and 5 to either the query about the spatial tests or that about AH4 (means - year 4, AH = 2.59, MHS = 2.68; year 5 - AH4 = 2.39, MHS = 2.38, the higher the response, the less the reported enjoyment).

In Chapter 6, I shall return to this and see if the lower intercorrelations for year 5 can be interpreted in terms of either differential correlational trends for the sexes or in terms of age trends. It should be noted, here, however, that these low intercorrelations allow no inferences about underlying factors to be drawn for this age group.

Factor Analyses

In summary then, the correlation matrices for the whole sample and the first four years show evidence both of a spatial factor and a general factor. Two factor analyses were performed on the matrices. In the first analysis done the technique used was a principal component analysis (Table 15A). This had been done in the first project because it is the technique most commonly used in relevant studies (Vernon, 1972, Yen, 1975B, Satterly, 1976). Furthermore, it places the least subjective restrictions on the data. However, in doing so, it assumes

TABLE 15A: PROJECT TWO: FACTOR ANALYSIS OF NINE TESTS: TOTAL SAMPLE (n = 190) (PRINCIPAL COMPONENTS ANALYSIS)

	FACTOR 1	FACTOR 2
MS1	.809	-.185
MS2	.856	-.124
MS3	.683	-.222
MS4	.615	.283
MS5	.678	.029
TOTMS	.980	-.088
COMPLACE 2	.148	.902
MAP 2	.599	.284
AH4	.572	.007
% VARIANCE	48.4	12.0

that there is minimal unique variance for each variable. While this assumption is, I think justified in project one where all the variables intercorrelated reasonably well (See Table 10, p. 142) it is, I think, a less acceptable assumption for project two where as Table 14 (p. 158) shows, COMPLACE 2 , correlates significantly with only one other variable[1].

Thus a second factor analysis was performed (see Table 15B). In this analysis, the diagonal of the correlation matrix was replaced with successive communality; estimates using an iterative technique to improve these estimates (see Nie et al., 1975, pp 479 - 480).

I will discuss Table 15A first. It will be remembered that in this analysis, no allowance is made for the unique variance of variables; all the variance is regarded as being theoretically accountable for in terms of the principal components only. Inspection of Table 15A will show that the first factor loads heavily on all the variables except COMPLACE 2. As in the first project this factor can be regarded as g. It is difficult to interpret the second factor unless it is regarded as an artefact of the method of factoring. This is most likely as it loads so heavily on COMPLACE 2 and I think it will be seen that this type of analysis is clearly unsuitable for the data in that the underlying model makes no allowance for the specificity

1. In project one, COMPLACE 1 and COMPDIRE both correlate significantly with all the other tests.

TABLE 15B: PROJECT TWO: FACTOR ANALYSIS OF NINE TESTS: TOTAL SAMPLE (n =190) (CLASSICAL FACTOR ANALYSIS WITH ITERATIONS, AXES NOT ROTATED

	FACTOR 1	FACTOR 2
MS 1	.821	-.307
MS 2	.867	-.125
MS 3	.697	-.312
MS 4	.625	.674
MS 5	.688	.246
TOTMS	.994	-.025
COMPLACE 2	.114	.174
MAP 2	.504	.073
AH 4	.480	-.093
% VARIANCE	47.3	8.5

that COMPLACE 2 clearly displays in the correlation matrices I presented.

Turning to the second factor analysis (Table 15B) which takes the specificity of tests into account by replacing the diagonal of the matrix by estimates of the communality, it will be seen that once again two factors are produced. Once again the first factor may be regarded as *g*. The second factor would appear to be a spatial factor loading on two of the MS sub-tests on COMPLACE 2 and minimally on MAP 2. Making a further assumption that the spatial factor was not independent of the *g* factor, I performed an oblique rotation of the axis to obtain the factors reported in Table 15C.

TABLE 15C: PROJECT TWO: FACTOR ANALYSIS OF NINE TESTS: TOTAL SAMPLE (n = 190) (CLASSICAL FACTOR ANALYSIS WITH ITERATIONS, OBLIQUE ROTATION OF AXES)

	FACTOR 1	FACTOR 2
MS1	.922	-.125
MS2	.838	.083
MS3	.818	-.161
MS4	.086	.880
MS5	.431	.436
TOTMS	.880	.222
COMPLACE 2	-.019	.216
MAP 2	.388	.205
AH4	.478	.020

r $factor_1$ $factor_2$ = .42156

Inspection of Table 15C will show once again that the first factor is best interpreted as g. The second factor now appears to be a spatial factor loading as it does on MS4, MS5, the total MS score, COMPLACE 2 and MAP 2. It will be seen that it doesn't load at all on AH4, lending further support to the interpretation that it is a spatial factor. However it should be noted that it does not load on MS1 or MS3 and loads only marginally on MS2.

In choosing Table 15C as representing the best explanation of the data, I have made three assumptions. The first is clearly justified I think. This is that the appropriate technique of analysis was one that made allowance for the uniqueness or specificity of COMPLACE 2. The second assumption I made was that the second factor was not independent of the first. This assumption led me to make an oblique rotation of the factors presented in Table 15B. My justification for this is two-fold. Inspection of the correlation matrix suggested that the factors were not independent and secondly as Nie et al write 'oblique rotation ... is more realistic because the theoretically important underlying dimensions are not assumed to be unrelated to each other' (P. 483). The third assumption lay in the choices of the degree of obliqueness[1]. I chose a default option for the rotation which assumes a 'fairly oblique solution' (Nie et al., 1975, p. 486)[2].

Partial Correlations

Further evidence for a spatial factor comes from an inspection of the residual correlation matrix resulting after the AH4 scores are partialled out. Table 16 shows that, unlike project one, after extraction of the non-spatial element, the correlation coefficients still remain highly correlated, with the exception of those intercorrelating COMPLACE 2.

In summary then the data yielded by project two, unlike the data yielded by project one, show evidence of an underlying spatial factor as well as a *g* factor, although this factor does not load on MS1 or MS3 and loads only marginally on MS2. I will return to this in the discussion at the end of this chapter, and in the next chapter.

Reporting Results - 2. Does the Spatial Factor have Two Components?

Michael et al. (1957) have described spatial ability as having two

1. Using the SPSS programme 'indirect oblimin' (Nie et al., 1975, p 486).
2. I did in fact also perform an orthogonal rotation which produced a very similar factor pattern to Table 15C differing only in that it produced a small loading on AH4, for the second factor.

TABLE 16: PROJECT TWO: PARTIAL CORRELATION MATRIX OF EIGHT TESTS CONTROLLING FOR AH4 (TOTAL SAMPLE)

(n =190) (PEARSON'S CORRELATION COEFFICIENTS)

	MS2	MS3	MS4	MS5	TOTMS	COMPLACE 2	MAP 2
MS1	.5793***	.4852***	.3055***	.3695***	.7956***	.0152	.2886***
MS2		.4194***	.3940***	.4254***	.8695***	.0184	.2973***
MS3			.3070***	.3102***	.6286***	.0102	.1406*
MS4				.3355***	.5960***	.1621**	.2638***
MS5					.6405***	.0647	.3065***
TOTMS						.0654	.3665***
COMPLACE 2							.1482*

Key *** = $p \leq .001$ ** = $p \leq .01$ * = $p \leq .05$

components - spatial visualization and spatial orientation. In project two four of the tests fit fairly clearly into the definitions of these (see p. 133).

Both MS1 and MS3 may be regarded as tests of spatial orientation and MAP2 and MS5 as tests of visualization. Table 17 summarises their intercorrelations.

TABLE 17: PROJECT TWO: INTERCORRELATIONS OF TESTS OF SPATIAL ORIENTATION AND SPATIAL VISUALIZATION: TOTAL SAMPLE (n = 190)

		ORIENTATION		VISUALISATION	
		MS1	MS3	MS5	MAP 2
ORIENTATION	MS1		.5426(.4852)	.4300(.3695)	.3692(.2886)
	MS3			.3836(.3102)	.2398(.1406)*
VISUALIZATION	MS5				.3741(.3065)
	MAP 2				

Partial coefficients after AH4 has been partialled out in brackets.

All coefficients except * significant at .001 level,

* significant at .05 level.

Table 17 shows that the intercorrelation of the two tests of spatial orientation is higher than their intercorrelations with either of the two tests of visualization both before and after AH4 is partialled out. However the intercorrelation of the two visualization tests is not higher than their intercorrelations with tests of orientation in two out of four cases.

Thus limited support is offered in my data for the dichotomy. It should however be noted that my measures of these factors are too short to be reliable enough to make more than a very superficial test of the dichotomy.

Reporting Results - 3. Two and Three Dimensional Tests

I shall not discuss the dimensionality of the tests used in project one in view of the low spatial component I have shown these tests to contain. With respect to the second project, the dimensionality of tests will be referred to mainly in the context of sex differences in the next chapter.

Table 15C shows that it is not possible to associate the dimensionality of tests directly with their factor loadings. MS1 and MS2, the two

two-dimensional tests do both show relatively high *g* loadings and low spatial loadings but so does MS3 which is a three dimensional test.

Discussion

In this chapter I have examined my own data in the light of Vernon's hierarchical model of human abilities. I have shown that the quasi spatial tests I used in project one, are highly saturated with *g* and that there is little evidence for a general spatial factor underlying performance at these tests. The common variance underlying the two directional tests appears from the correlational and factor analyses to be fairly specific to these tests and data from the small longitudinal sample confirms this impression. As Table 14B (p 161) shows, correlating the two directional tests with the spatial tests used in project two yields only 3 of a possible 12 significant correlations.

The high *g* loadings of the quasi-spatial tests has important implications for the fourth of the five summary points made in Chapter One. It would seem that inconsistent sex differences on quasi-spatial tests and tests of field independence for children are explicable in terms of their high *g* and relatively low spatial loading. It may be that where sex differences are shown in studies on tests of this nature, these may be more ascribable to differences in *g* than to differences in spatial ability. I shall return to this discussion in the next two chapters, when I consider sex differences on tests of *g* and the developmental nature of these differences.

In project two, both the correlational and factor analyses and the residual correlational matrix showed that the spatial and quasi-spatial tests used were loaded with *g* and to differing degrees with a spatial factor. Bearing in mind that the factor analysis in Table 15C rests on three assumptions, it is nevertheless interesting to note that (see p 172) three of the five spatial sub-tests of the MH test are heavily loaded with *g* and minimally loaded with the spatial factor. The first factor analysis which makes no subjective assumptions at all about the data also shows (see Table 15A, p. 169) dissimilar factor loadings for the five spatial sub-tests on the second factor. I think it is fair to conclude that, definitions such as that used by Garei and Scheinfeld of spatial ability are not rigorous enough. In their influential monograph on sex differences they defined spatial ability as being shown on 'tasks requiring the perception, judgement and manipulation of spatial relationships' (1968, p. 106). All the spatial and quasi-spatial tests used in my two projects would appear to fit such a definition yet it has been shown on analysis that such tests are not best described as loading mainly on a spatial factor.

It is not only my data that show such high loadings on spatial and quasi-spatial tests. I will discuss two studies which show comparable results.[1]

In the first, Wolf (1971) administered the following tests to 74 eleventh grade children - a spatial visualization test, a vocabulary test, embedded figure tests, a digit-span test and a concept-fluency test. He reported factor analysis results as follows; 'the first factor appears to be related to general ability; it is associated with IQ, vocabulary, spatial perception, and the group-administered version of Wolf's Embedded Figures Test'. The second factor loaded on the EFT used and the fluency tests and was regarded as a creativity factor. The third factor loaded on the spatial test, the EFT and the digit span task. This last factor according to Wolf 'may represent

1. The study referred to before (pp 135-136) by Hyde et al. (1975) also showed similar results.

a visualization ability or an ability to work in short-term memory'.

Satterly (1976) tested 201 boys aged 10 to 11 years, on a battery of tests that included embedded figures, haptic perception and a spatial factor besides intelligence and scholastic ratings. He extracted four principal components. The first of these was regarded as a general factor, the second as a factor of 'flexible thinking' (Satterly, p. 40), the third a spatial factor and the fourth perceptual speed. From the comparative point of view, it is interesting to note that embedded figures loads .307 on factor 1 and -.307 on factor 3 and that haptic perception loads .323 on factor 1 and .229 on factor 3.

Thus, I think it may be said that unless a test battery includes some measure of general ability, it is not satisfactory to ascribe the common variance to a spatial factor as Yen does (see p 165 of this study). Further, if sex differences are observed on such a battery, it is not rigorous enough to ascribe these to differences in spatial ability. I shall show in Chapter 6 that concurrent with increasing sex differences on tests of spatial ability in favour of boys, there tends to be increasing sex differences on verbal reasoning abilities in favour of boys.

With respect to the two conjectured components of spatial ability - visualization and orientation, my own tests did not produce results which allowed for the inference of these components. On the basis of her study, Yen (1975) has claimed that sex differences are more likely to be genetically based on tests of two-dimensional visualization. However, my data does not clearly distinguish between two and three dimensional tests, and as I mentioned on pages 177 - 178 no association was obvious between dimensionality and factor loadings in the spatial sub-tests of project two.

A study by Shepard and Metzler (1971) offers some support for this finding. They conducted a study with two and three dimensional shapes that were represented by line drawings. Subjects had to identify correctly rotations of reference shapes. Their results indicated that the time required (and therefore, presumably, the abilities drawn upon) was no shorter for differences corresponding simply to a rigid rotation of one of the two-dimensional drawings in its own picture plane than for differences corresponding to a rotation of the three-dimensional object in depth' (p. 701).

In summary, then, my contention in this chapter has been to show that tasks that have been labelled as tests of spatial ability, do not always mainly measure so specific an ability. The spatial and quasi-spatial tests I used all load on *g*. The tests of direction seem to measure mainly a specific ability and do not appear to be highly loaded with a spatial factor. The five spatial tests of project two and the map visualization test of this project (MAP2) all load on *g* and three of the six to varying degrees on what has been labelled as a spatial factor.

Right through this chapter, I have made no differentiation between the sexes in considering the correlational and factor analyses. In the next chapter, which deals with sex differences, I will first inspect sex differences on raw scores. After that I will explore in depth whether the tests I used in my two projects load similarly for boys and girls on the two components of spatial tests, *g* and spatial ability. Is it possible that sex differences lie in the approach to spatial tests? Are more girls than boys likely to utilise symbolic or verbal strategies, such as were used by the blind subjects tested by Marmor and Zaback (1976) (see pages 122 - 123)? Do spatial tests contain a higher *g* component for girls than boys?

It would seem then, that any attempt to define spatial ability should be deferred until sex differences on the factor loadings of tests regarded as being of a spatial nature have been discussed.

Addendum to Chapter 4

In order to further clarify the nature of what I called the general factor, it was decided to rework the factor analyses for both projects using the partial correlation matrices from which age had been partialled out. Tables 11A and 15D (below) show the results of these reworkings. Comparison of these tables with the factor analyses previously presented (Tables 11 and 15C) shows that the underlying factor structure is unchanged for both projects and therefore the conclusions are unaltered.

Turning to project one first and comparing Table 11A (below) with Table 11 (p. 152) the similarity in underlying factor structure is clear and therefore the conclusions following Table 11 (pp 152-3) remain unchanged.

For project two, in addition to partialling out age, TOTMS was omitted from the analysis. Comparison of Table 15D (below) with Table 15C (p. 172) shows that Factor 1 is very similar for the two analyses except that now MS4 also loads on this factor. Factor 2 is similar in structure for both analyses as well, though it accounts for rather less of the variance

CHAPTER FIVE : SEX DIFFERENCES IN THE TWO PROJECTS

Introductory Note

In this chapter I shall report the results concerned with sex differences separately for the two projects. However in the discussion following the results I shall try to synthesize the two sets of findings. For both projects I shall first report the results of statistical tests on the raw scores and then present correlational and factor analyses by sex, using the model of human abilities presented in the last chapter.

Reporting Results - 4. Sex Differences in Project One

(A) Raw scores

In the last chapter I suggested that much of the variance on the five quasi-spatial tests used was due to g. Thus it is of interest to compare the scores on the two WISC tests (PICT and SIML) that were used to estimate this. Table 18 shows that there was a tendency for boys to score higher at these two tests. In the case of PICT this difference was significant for the total sample ($p \leq .05$).

It might be thought that this tendency for the boys to score higher at these two tests reflected merely a better adaptation to the test situation rather than an actual difference in general intelligence. However the results of the CODING sub-test do not confirm this hypothesis (Table 18). Girls performed significantly better at this test and thus it does not seem likely that the higher scores on PICT and SIML were due to motivational or attentional factors.

There is no obvious explanation for the higher *g* scores of the boys in the sample tested in project one. However some studies do show male superiority on the WISC and Standford-Binet at this age (Brown and Bryan, 1955, Jones, 1962). I will return to this question in the discussion at the end of this chapter. At this stage I would like to note that any findings in the area are not necessarily very stable[1].

The tendency for boys to have slightly higher levels of scores on these two estimates of *g* will be seen to have important implications for results on the quasi-spatial tests as these have been shown to

1. For example, Garner et al. (1971) investigating groups of five to seven year olds found that sex differences on WISC scores may change direction on crossing an English county border. Boys significantly outscored girls overall in Warwickshire, but the difference was reversed in a larger group in Lancashire.

TABLE 18: t-TEST ON SEX DIFFERENCES ON THE THREE WISC SUB-TESTS USED IN PROJECT ONE, TOTAL SAMPLE AND BY YEAR

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
PICT		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	29.41	24.00	29.93	29.64	31.14	32.57
	s.d.	6.68	6.42	7.67	4.61	3.63	8.52
GIRLS	mean	26.86	19.93	24.07	30.21	29.14	30.93
	s.d.	8.38	9.49	9.60	6.07	3.80	6.62
t		1.97	1.33	1.78	-0.28	1.42	0.58
Prob level		.05*	n.s.	n.s.	n.s.	n.s.	n.s.

KEY * = $p \leq .05$. Positive values of t indicate differences in favour of boys

Negative values of t indicate differences in favour of girls

TABLE 18 (cont.)

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
SIML		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	13.53	10.79	13.07	13.64	14.79	15.36
	s.d.	3.87	3.21	2.27	3.71	4.06	4.46
GIRLS	mean	12.63	8.57	11.57	12.50	15.14	15.36
	s.d.	4.01	2.77	3.86	3.18	2.24	3.63
t		1.35	1.95	1.25	0.87	-0.28	0.00
Prob level.		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY Positive values of t indicate differences in favour of boys.

Negative values of t indicate differences in favour of girls.

TABLE 18 (cont.)

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
CODING		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	36.57	29.93	30.36	38.36	40.21	44.00
	s.d.	9.47	7.93	5.11	8.14	9.44	8.08
GIRLS	mean	39.79	34.64	32.93	39.00	43.71	48.64
	s.d.	9.65	6.99	7.79	9.13	9.03	6.21
t		-1.99	-1.67	-1.03	-0.20	-1.00	-1.70
Prob level		.05*	n.s.	n.s.	n.s.	n.s.	n.s.

KEY * = $p \leq .05$ Negative values of t indicate differences in favour of girls be highly loaded with *g* (chapter 4). It is for this reason that the t-tests on the tests are accompanied by analyses of variance in which SIML and PICT as well as age have been partialled out[1].

Quasi-spatial Tests

Table 19 summarises sex differences on the embedded figure test (EFT). It will be remembered that this test tends to show a relatively high *g* loading both in my own study (chapter 4) and in others. (See for example Satterly, 1975 and Wolf, 1971, referred to on pages 180-1). No significant sex differences are shown for this test for the total sample. In Primary Four a significant difference is shown, in favour of boys, on a t-test, and after WISC and SIML are covaried out, (see analysis of variance table, Appendix VII for full details of analysis) this difference remains significant. As only three of the five years show a directional difference in favour of boys and as the only significant difference occurs in Primary Four, this test cannot be said to show clear sex differences in favour of boys.

1. Appendix VII contains the analyses of variance by test, by total and by form.

TABLE 19: PROJECT ONE: SUMMARY OF SEX DIFFERENCES ON EFT, TOTAL SAMPLE AND BY YEAR

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	9.04	7.29	8.36	10.57	8.50	10.50
	s.d.	2.99	2.95	1.95	3.34	2.96	2.50
GIRLS	mean	8.26	5.57	6.14	8.50	9.64	11.43
	s.d.	3.53	2.03	1.70	3.59	2.47	3.84
t		1.42	1.79	3.20	1.58	-1.11	-0.76
Prob. level (t)		n.s.	n.s.	.004**	n.s.	n.s.	n.s.
F		0.24	0.51	6.72	3.91	1.31	0.88
Prob. level (F)		n.s.	n.s.	.02*	n.s.	n.s.	n.s.

KEY ** $p \leq .01$ — F level refers to analysis of variance with age and (SIML and PICT) covaried.

* $p \leq .05$ — Positive values of t indicate boys' superiority, negative values girls'.

Table 20 summarises sex differences on the maze test used (MAZE) . Although five out of six comparisons are in favour of boys, the differences are so small as to indicate no sex differences (reference to the relevant analysis of variance tables, Appendix VII pp 482-7 will show the probability level to be .99 for all comparisons).

As Table 21 indicates, a positive sex difference is shown in favour of boys for the total sample on the test of visualization (MAP 1) that was designed for this age group. Reference to the appropriate analysis of variance table (Appendix VII, page 488) shows that the difference remains significant even after age and the measures of *g* are covaried. However as Table 21 makes clear, the major sex differentiation occurs in Primary Seven. Indeed, a t-test on Primary Three to Six inclusive shows no sex difference, ($t = 1.32$). An analysis of variance for these four age groups totalled confirms this (see Appendix VII, Page 494). No main effect for sex is shown when *g* and age are covaried. It seems fair to conclude that the sex differentiation on this variable is largely due to the relatively poor scores of the girls in this age sample (Primary Seven) who scored less than the girls in both Primary Five and Primary Six.

TABLE 20: PROJECT ONE: SUMMARY OF SEX DIFFERENCES ON MAZE, TOTAL SAMPLE AND BY YEAR

		TOTAL (n=140)	PRIMARY 3 (n=28)	PRIMARY 4 (n=28)	PRIMARY 5 (n=28)	PRIMARY 6 (n=28)	PRIMARY 7 (n=28)
BOYS	mean	11.96	10.57	11.43	13.11	12.29	12.39
	s.d.	2.09	2.64	2.07	1.74	1.54	1.61
GIRLS	mean	11.59	9.75	11.18	12.86	11.75	12.39
	s.d.	2.14	1.64	11.64	1.18	2.64	2.06
t		1.04	0.99	0.35	0.44	0.66	0.00
Prob. level (t)		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
F		0.19	0.22	0.17	0.06	0.61	0.00
Prob. level (F)		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

F level refers to analysis of variance with age and (SIML and PICT) covaried.

Positive values of t indicate boys' superiority.

TABLE 21: PROJECT ONE: SUMMARY OF SEX DIFFERENCES ON MAP 1, TOTAL SAMPLE AND BY SEX

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	8.99	6.71	8.29	9.86	9.21	10.86
	s.d.	2.44	1.27	2.61	2.21	2.19	1.66
GIRLS	mean	7.96	6.79	7.21	8.21	9.57	8.00
	s.d.	2.20	1.93	1.63	2.12	2.07	2.35
t		2.62	-0.12	1.30	2.01	-0.44	3.71
Prob.level (t)		0.01**	n.s.	n.s.	n.s. (.06)	n.s.	.001***
F		5.67	0.02	1.01	2.69	0.18	20.19
Prob. level (F)		0.02*	n.s.	n.s.	n.s.	n.s.	.001***

KEY *** $p \leq .001$ ** $p \leq .01$ * $p \leq .05$ F level refers to analysis of variance with age and (SIML and PICT) covaried. Positive values of t indicate boys' superiority, negative values girls'.

Table 22 summarises the sex differences on the directional test, COMPLACE 1 , which required the subject to point out locations in the neighbourhood of the school. Five out of six of the t-tests are directionally in favour of boys but only one of these is significantly so (Primary Seven). This difference remains significant even after the two measures of *g* have been partialled out (Appendix VII, page 500) Thus as with the MAP 1 test the only significant difference occurs in Primary Seven. I will return to this later in this section when I compare the two sets of scores of the 22 children in the longitudinal sample.

Table 23 summarises the sex differences on the other directional test COMPDIRE , which required the subject to point out compass directions. Reference to Table 23 and the analysis of variance for this test (Appendix VII, pp 501-6) indicates that these are non-significant.

In summary then, the raw scores on the quasi-spatial tests used in project one tend not to show sex differences. Though many of the initial comparisons are in favour of boys, this is not surprising in view of their higher *g* scores and the high *g* loading of the tests. However the analyses of variance which covary out the *g* scores and

TABLE 22: PROJECT ONE: SUMMARY OF SEX DIFFERENCES ON COMPLACE 1, TOTAL SAMPLE AND BY YEAR

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	145.50	120.57	144.46	148.97	152.66	160.83
	s.d.	28.45	33.21	20.94	24.68	24.68	21.06
GIRLS	mean	137.43	118.67	129.51	148.14	152.94	137.91
	s.d.	32.18	39.86	20.06	24.77	30.31	27.54
t		1.57	0.12	1.60	0.09	-0.03	2.47
Prob. level (t)		n.s.	n.s.	n.s.	n.s.	n.s.	.02*
F		1.21	0.36	1.56	0.08	0.02	7.19
Prob. level (F)		n.s.	n.s.	n.s.	n.s.	n.s.	.01**

KEY ** $p \leq .01$
* $p \leq .05$

F level refers to analysis of variance with age and (SIML and PICT) co-varied.

Positive values of t indicate boys' superiority, negative values girls'

TABLE 23: PROJECT ONE: SUMMARY OF SEX DIFFERENCES ON COMPDIRE, TOTAL SAMPLE AND BY YEAR

		TOTAL	PRIMARY 3	PRIMARY 4	PRIMARY 5	PRIMARY 6	PRIMARY 7
		(n=140)	(n=28)	(n=28)	(n=28)	(n=28)	(n=28)
BOYS	mean	110.82	92.43	104.13	120.97	107.87	128.67
	s.d.	47.33	38.19	40.36	57.19	57.24	36.85
GIRLS	mean	99.92	94.83	92.87	93.14	111.81	106.91
	s.d.	55.04	30.42	19.77	40.90	47.48	42.01
t		1.51	-0.18	0.94	1.48	-0.20	1.46
Prob. level (t)		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
F		1.27	0.00	1.81	1.21	0.09	2.68
Prob.level (F)		n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY Positive values of t indicate boys' superiority, negative values girls'.

F level refers to analysis of variance with age and (SIML and PICT) covaried.

age only indicates four significant intersex differences out of thirty comparisons all in favour of boys. These are:

<u>One on the total sample on MAP 1</u>, however there is no difference on Primary Three to Six inclusive on this test, i.e. the intersex difference occurs mainly in Primary Seven.

<u>One on Primary Four on EFT</u>

<u>Two on Primary Seven on MAP 1 and COMPLACE 1</u>

It would thus seems that there are some indications of sexual differentiation in Primary Seven, two out of the five quasi-spatial tests yielding sex differences in favour of boys, after the measure of *g* had been covaried out. However when most of these children (22 out of 28) were re-tested the following year as part of the first year sample of project two, the same sex differences were not shown. Table 24[1] summarises the data for this small longitudinal sample. It will be seen in the case of the equivalent directional tests (COMPLACE 1 and COMPLACE 2) the directional trend was reversed - the girls scoring marginally more on the second test battery.

1. No analyses of variance are performed on the data of Table 24 as there were non-significant differences in the measures of *g* for these children.

TABLE 24: SUMMARY OF SEX DIFFERENCES IN LONGITUDINAL SAMPLE TESTED IN BOTH PROJECTS (boys = 11, girls = 11)

	PROJECT ONE						PROJECT TWO						
	EFT	MAZE	COMP 1	COMPD	MAP 1	MS1	MS2	MS3	MS4	MS5	TOTMS	COMP2	MAP2
BOYS mean	10.27	12.27	163.89	133.93	10.64	6.64	14.00	4.09	4.00	2.27	31.00	8.64	10.09
s.s.	2.61	1.72	20.34	39.05	1.80	3.11	5.16	1.51	2.37	2.05	10.20	3.41	3.89
GIRLS mean	11.82	12.22	138.98	100.80	8.09	4.09	14.18	3.27	3.82	1.44	26.82	9.09	8.73
s.d.	4.11	2.18	28.78	41.35	2.34	4.35	7.12	1.56	2.64	1.75	14.13	1.51	2.64
t	-1.05	0.05	2.34	1.93	2.85	1.58	-0.07	1.25	0.17	1.00	0.80	-0.40	0.96
Prob. level	n.s.	n.s.	.03*	n.s.	.01**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY ** $p \leq .01$ * $p \leq .05$ Positive values of t indicate boys' superiority, negative values girls'.

COMP COMPLACE 1 COMPD COMPDIRE

I will return to this inconsistency at the end of this chapter, but would point out, at this stage, that such instability seems characteristic of sex differences in this age group and furthermore that the quasi-spatial tests of project one did not correlate highly with the spatial tests of project two (see Table 14B).

(B) The Keogh Tests

Keogh examined sex differences in pattern copying. I have already described her methodology in Chapter 3 (pp 100 - 101). She asked her subjects to copy patterns either by drawing or by walking the patterns (which can be seen on pp 575-577 of this study). She obtained the following results:

(i) Boys obtained higher scores than girls did for pattern walking (Table A32, Appendix VII). Keogh used three walking conditions (see Chapter 3, pp 102-103) floor, mat and sand. Further, she reported no significant differences for pattern drawing as between boys and girls but did not give probability levels.

(ii) Girls scored significantly higher at drawing than they did at walking but boys did not. Thus she concluded, in terms of the two findings just described 'boys were better than girls in ability to make patterns by walking in an expanded spatial field' (Keogh, 1971, p. 29).

(iii) 'Subjective' differences in walking were apparent. No figures were given for this but she reported 'Boys made precise angles and corners, were accurate in starting and stopping points, and indicated clearly when a pattern was completed. Boys appeared to make complex patterns in sub-units, completing one part and pausing or stopping before beginning the next part. Girls walked hesitantly, made rounded corners and imprecise angles, starting and stopping points were not coordinated, and patterns were left incomplete'(p. 29).

She interpreted her findings[1] as showing that boys organise space better and as indicating sex differences in perceptual style.

In my own study I asked my subjects to both draw and walk the nine

1. She also found that the more visual cues that were afforded, the better boys but not girls did. This was calculated by comparing the three walking conditions she used ('floor', 'mat' and 'sand', see pp102-103). As I only used one walking condition, I am unable to compare my results on this point to her's.

Keogh shapes. I used, however, only one walking condition and attempted to duplicate the 'sand' condition, choosing this, as I indicated in Chapter 3, because it showed the greatest sex differences (see Table A32, Appendix VII), and because it was possible to make a permanent record of this condition that could be scored later by a rater who was unaware of the subject's sex. With reference to Keogh's three findings listed above, my own study indicated:

(i) Boys did not score higher than girls at pattern walking (see Table A33, Appendix VII). They did score higher for pattern drawing. Neither of these two findings accord with Keogh's that boys are relatively better than girls at walking but not at drawing.

(ii) Girls did not score higher at drawing than they did at walking as Keogh's girls did. On the contrary my sample of girls scored significantly higher on total scores at walking than they did at drawing (See Table A34, Appendix VII).

Comparison of Table A32 and A33 (Appendix VII) indicates that the mean scores were rather lower for my sample than they were for Keogh's. This probably shows that my rater used the criteria listed in Chapter 3 (page 101) rather more strictly than Keogh's raters did. However this does not affect the comparability of the two studies as all comparisons are in terms of t-tests between the sexes <u>within</u> the studies.

(iii) Table A35, Appendix VII lists my results on the subjective criteria Keogh employed. It will be seen that rather more girls were rated as walking hesitantly than boys (five girls compared with two boys), thus offering some support for one part of Keogh's last findings. There were no differences on the other two subjective criteria.

In general it will be seen from Table 25 that the study offers little support for Keogh's findings. However a major tenet of the present study is that small scale investigations of sex differences are bound to show slight and unreliable differences that shift from sample to sample and age to age. Indeed the tenuous nature of such sex differences is clearly seen by examining the drawing scores on Keogh shapes for the Primary Three sample I tested[1]. Whereas the boys in Primary

1. Nine additional shapes were added to the Keogh battery (See Chapter Three, page 97). These were designed to resemble everyday objects and the children were supplied with the appropriate verbal labels, on the hypothesis that meaningfulness of stimuli would interact with sex of subject. These results are reported in Chapter Seven.

TABLE 25: COMPARISON OF KEOGH'S RESULTS WITH RESULTS OF PROJECT ONE (SIANN). KEOGH'S 'SAND' CONDITION, SIANN'S 'CHALK' CONDITION.

Point (pp 201 - 3)	KEOGH'S RESULTS	SIANN'S RESULTS	AGREEMENT?
(i)	Boys score more than girls at walking but not drawing (Table A32)	Boys score more at drawing but not walking (Table A33)	NO
(ii)	Girls score more at drawing than walking.	Girls score more at walking than drawing	NO
	No difference for boys. (Table A32)	No difference for boys (Table A34)	NO
(iii) (a)	Boys more likely to indicate clearly when pattern completed.	13 boys indicate clearly. 13 girls indicate clearly.	NO
(iii) (b)	Boys more likely to make patterns in sub-units.	11 boys did so 13 girls did so	NO
(iii) (c)	Girls more likely to walk hesitantly	2 boys hesitant 5 girls hesitant	YES
	(No figures given by Keogh)	(Table A35)	

Four scored significantly better than the girls in this year at all three measures of drawing (Table A33). In Primary Three no significant sex differences on drawing were shown. On two of the three comparisons girls scored directionally better, so that even the directional effect was reversed.

(C) Correlational Matrices

Table 26 shows the correlational matrices for the two sexes, for the total sample on the tests of project one. Pearson's correlation coefficients were used and these have been corrected to two decimal places for ease of comparison. In addition two more variables have been included. The first of these is WALK and this is an average score for the degree of mobility the children displayed in their answers to the questionnaire about this (p 432-3 of Appendix II). This variable displayed no difference between the sexes on a comparison of raw scores (boys, mean = 4.714, s.d. = 1.495; girls, mean = 4.671, s.d. = 1.567) but displays rather different patterns of correlation for the two sexes, as will be shown.

COMBETT is a subset of the answers to COMPDIRE, the test of location of direction. It consists of the mean scores for North and East only

TABLE 26: PROJECT ONE: INTERCORRELATIONS OF NINE MEASURES FOR TOTAL SAMPLE BY SEX (PEARSON'S CORRELATION COEFFICIENT)(Boys = 70, girls = 70)

		PICT	EFT	MAZES	COMPL	COMPD	COMB	MAP 1	WALK
	SIML	.48***	.48***	.25*	.35**	.21*	.25*	.27**	.40***
		.60***	.60***	.41***	.26*	.27**	.15	.41***	.41***
1	PICT		.29**	.30**	.35***	.14	.13	.30**	.29**
			.52***	.50***	.29**	.10	.17	.32	.28**
	EFT			.18	.37***	.26**	.26**	.39***	.35**
				.41***	.32**	.21*	.10	.40***	.42**
2	MAZES				.14	.01	.01	.39***	.31**
					.11	.23*	.25*	.24*	.24*
	COMPL					.47	.42**	.34**	.51***
						.17	.03	.17	.32***
	COMPD						.95***	.31**	.27**
							.88***	.24**	.03
3	COMB							.27**	.32**
								.07	.08
	MAP 1								.47***
									.21*

KEY *** p ≤ .001 ** p ≤ .01 * p ≤ .05 COMPL COMPLACE 1

COMPD COMPDIRE COMB COMBETT Girl's coefficients in boxes as it was thought that particularly the older children might have calculated the answers arithmetically to the other four directions rather than answered with reference to a directional sense only. COMBETT shows no significant sex differences on raw scores ($t = 0.94$, boys mean = 105.88, s.d. = 52.97: girls mean = 99.24, s.d. = 41.55) but like COMPDIRE displays rather different correlation patterns between the two sexes.

I have grouped the variables into three sets. The first are the two measures of *g* taken from the WISC (SIML and PICT). The second group comprises the two quasi-spatial tests that are quoted in the literature as providing estimates of *g* (MAZE, see Porteous, 1956, and EFT, see Satterly, 1976). The third group are those measures that appear to include an element of directional ability (COMPDIRE, COMBETT, COMPLACE 1, MAP 1 and WALK).

Two points emerge from comparing the correlation matrices for the sexes:

(i) There is a tendency for the first two groups of tests to intercorrelate more highly for the girls than for the boys. (6 out of 6 comparisons, 2 at the .10 level of probability). This is taken to indicate that a general factor seems to contribute more to the first two groups for the girls than for the boys.

(ii) There is a tendency for the boys' scores in the third group to intercorrelate more highly than the girls (10 out of 10 comparisons, 2 at .05 level, 4 at .10 level and 4 non-significantly. This is taken to indicate that a common factor contributes more to the boys' scores on the third set than to the girls'. As this common variance seems independent of the variance on SIML and PICT for the boys, it would seem to indicate an aptitude or special factor for the boys but not for the girls.

Thus it would seem that although raw scores do not reveal large intersex differences in project one, comparison of the correlation matrices reveals some clear differences.

(D) Factor Analysis and Partial Correlation Matrices

In Chapter 4 I used a principal component analysis to examine the underlying factors in project one. As Table 11 showed (p. 152) a clear first factor was revealed and this was labelled as a general factor. The second factor was rather more difficult to interpret, loading as it did, positively on the two directional tests COMPLACE 1 and COMPDIRE and negatively on MAZE and PICT. Rotating the factors (see Table A36, Appendix VII) did not clarify the second factor, as it loaded after rotation on SIML as well as continuing to load negatively on MAZE.

In the light of Table 26, the lack of clarity on these analyses seems comprehensible. Presumably it springs from treating the sexes together when their correlation matrices differ fairly appreciably. Thus Table 27A shows the principal component analysis repeated for the sexes separately. Clear sex differences are shown. For the girls all the shared variance is explicable by means of a general factor[1] whereas for boys two factors emerge. Again the first of these is clearly a general factor. It is however less easy to interpret the second, with its high negative loadings on MAZE and PICT. An oblique rotation (Table 27B) produced similar results.

It was thus decided to do a classical factor analysis, as was done for project two. This makes allowance for the specificity of tests by continued iterations of communality estimates (see Chapter 4, page 170). In addition an oblique rotation was done on the same theor-

1. The programme I used deletes all factors with an eigenvalue of less than one which is the generally accepted minimum (Nie et al., 1975,p 493)

TABLE 27A: PROJECT ONE: FACTOR ANALYSIS OF SEVEN TESTS BY SEX.

(PRINCIPAL COMPONENTS)

	BOYS (n = 70)		GIRLS (n = 70)
	Factor I	Factor II	Factor I
EFT	0.690	0.068	0.795
MAZE	0.464	-0.664	0.651
COMPLACE 1	0.694	0.338	0.456
COMPDIRE	0.517	0.670	0.404
MAP1	0.674	-0.107	0.599
SIML	0.709	-0.132	0.818
PICT	0.659	-0.287	0.776
% VARIANCE	40.45	16.00	43.68

etical grounds as were discussed for project two (Chapter 4, p 172). Table 28 gives the results of this analysis. It would appear to produce more meaningful results than the other two analyses (Tables 27A and 27B) did.

For the boys, the general factor loads on all tests except COMPDIRE. A second factor loads on all the quasi-spatial tests, except MAZE

TABLE 27B: PROJECT ONE: FACTOR ANALYSIS OF SEVEN TESTS BY SEX (PRINCIPAL COMPONENTS WITH OBLIQUE ROTATION)[1]

	BOYS (n = 70)		GIRLS (n = 70)
	FACTOR I	FACTOR II	
EFT	0.482	0.385	(As Table 27A - rotation
MAZE	0.802	-0.399	does not affect one
COMPLACE 1	0.262	0.684	factor solution)
COMPDIRE	-0.070	0.863	
MAP2	0.592	0.215	
SIML	0.637	0.209	
PICT	0.706	0.042	

and produces no loadings on either SIML or PICT. It may be thought of as a spatial factor, which, however, accounts for very little of the total variance.

1. The importance of a factor as indicated by 'variance accounted for' is of no particular interest in a rotated solution (Nie et al., 1975, p. 470), so variance calculations are not presented for rotated solutions.

TABLE 28: PROJECT ONE: FACTOR ANALYSIS OF SEVEN TESTS BY SEX (CLASSICAL FACTOR ANALYSIS WITH ITERATIONS, OBLIQUE ROTATION OF AXES)

	BOYS (n = 70)		GIRLS (n = 70)	
	FACTOR I	FACTOR II	FACTOR I	FACTOR II
EFT	0.556	0.119	0.772	0.055
MAZE	0.494	-0.163	0.526	-0.100
COMPLACE 1	0.437	0.329	0.357	0.000
COMPDIRE	0.007	0.996	0.056	0.952
MAP 1	0.526	0.130	0.480	0.024
SIML	0.654	0.041	0.789	0.000
PICT	0.643	-0.051	0.769	-0.073

$r_{\text{Factor I, Factor II}} = 0.285$ $r_{\text{Factor I, Factor II}} = 0.274$

For the girls, the first, general factor loads more highly on the non-directional tests than it does for the boys. The second factor loads only on COMPDIRE and thus cannot be regarded as a spatial factor of any generality.

I am fully aware, how subjective the choice of a method of factor analysis is. I do consider, however, that the most meaningful solution is yielded by the last method used (Table 28). However it is clearly not a subjective judgement, that which ever method of analysis is chosen, both the underlying correlation matrices and the factor analyses display differences between the sexes. I will return to this in the discussion. This intersex difference is additionally confirmed by inspection of the residual correlation matrices for the sexes. As Table 29 shows, after the estimates of *g* are partialled out, only one of the sixteen resulting correlations is significant for the girls, while nine are significant for the boys. Once again, as in Table 26, the coefficients have been corrected to two decimal places for ease of comparison.

Reporting Results - 4. Sex Differences in Project Two

A. Raw Scores

In project two there was only one measure of *g* - part I of the AH4 test of general intelligence (Heim, 1970). This test revealed significant sex differences but in contrast to the sex differences on the measures of *g* in project one, these were in favour of girls. Table

TABLE 29: PROJECT ONE: PARTIAL CORRELATION OF FIVE TEST MEASURES CONTROLLING FOR SIML AND PICT BY SEX (boys = 70, girls = 70) (PEARSON'S CORRELATION COEFFICIENTS)

	EFT	MAZE	COMPLACE 1	COMPDIRE	COMBETT	MAP 1
EFT		.06	.24*	.18	.17	.30**
		.16	.17	.08	-.02	.19
MAZE			.01	-.08	-.08	.31**
			-.07	.18	.18	.06
COMPLACE 1				.43***	.37***	.23*
				.12	-.02	.06
COMPDIRE					.95***	.26*
					.89***	.16
COMBETT						.22*
						.00

KEY *** $p \leq .001$ ** $p \leq .01$ * $p \leq .05$ Girls' correlations in boxes.

30 summarises the differences on AH4. It will be seen that there are significant differences in favour of girls for the total sample and for years three and five.

That there was an inconsistent sex difference on the measure of g over the two projects is not unexpected, in view of the instability of sex differences in this area, (see p 186). This inconsistency will be explored at the end of the chapter but as was noted for project one, sex differences in g must have important implications for sex differences on the spatial tests as these have been shown to load on a general factor. Thus, as was done for project one, t-tests on sex differences for the spatial and quasi-spatial tests, will be accompanied by analyses of variance on which the measure of g has been covaried out (all to be found in Appendix VII, pp 476 - 536).

The Spatial Tests

The first part of the Moray House space test was a test of two-dimensional orientation (MS1). Table 31 shows that a significant sex difference in favour of boys is shown for the total sample after the estimates of g and age have been covaried out. (See Appendix VII, pp 513 - 5 for the analysis of variance tables). As will be seen the major sex

TABLE 30: PROJECT TWO: t-TESTS ON SEX DIFFERENCES ON AH4, TOTAL SAMPLE AND BY YEAR

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	30.20	35.00	24.25	26.79	35.33	30.35
	s.d.	10.46	11.22	11.18	5.98	8.43	9.27
GIRLS	n	102	13	29	14	27	19
	mean	34.25	34.61	28.83	37.00	35.36	38.84
	s.d.	9.29	9.29	8.59	6.00	9.82	8.31
t		-2.80	0.10	-1.64	-4.51	0.03	-2.51
Prob. level		.006**	n.s.	n.s.	.005**	n.s.	.02*

KEY ** $p \leq .01$
* $p \leq .05$

Positive values of t indicates boys' superiority, negative value girls'.

TABLE 31: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON MS1, TOTAL SAMPLE AND BY YEAR

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	7.25	5.50	6.54	6.50	8.71	8.67
	s.d.	3.92	3.54	3.73	4.50	3.39	4.10
GIRLS	n	102	13	29	14	27	19
	mean	6.85	4.62	7.03	7.00	6.85	8.00
	s.d.	3.77	4.55	3.54	3.40	3.39	4.04
t		0.71	0.56	-0.49	-0.33	1.95	0.44
Prob level (t)		n.s.	n.s.	n.s.	n.s.	.05	n.s.
F		4.19	1.01	0.31	1.75	4.43	2.23
Prob. level (F)		.04*	n.s.	n.s.	n.s.	.04*	n.s.

KEY * $p \leq .05$ F level refers to analysis of variance with age and AH4 covaried.

Positive values of t indicate boys' superiority, negative values girls'.

differentiation on all the Moray House sub-tests occurs in the two older samples, in this case in the fourth year.

The second Moray House sub-test was a two-dimensional test that combined visualization and orientation (MS2). Table 32 indicates that the total sample shows no significant sex differences but that these are shown again for the fourth year in favour of boys.

Table 33 summarises sex differences on the third MS sub-test (MS3) which was a test of three dimensional orientation. This shows clear sex differences for the total sample and for the last two years in favour of boys. The appropriate analyses of variance can be found in Appendix VII pages 519 - 521.

Table 34 shows that the only sex difference on MS4 (a three-dimensional test that combined aspects of visualization and orientation) occurred in Year 4. This difference remained significant after age and AH4 had been covaried (see Appendix VII, pp 522 - 4). Thus the tendency for sex differences to be shown for the older groups is seen again.

The final part of the MS test is a three-dimensional test of visualization

TABLE 32: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON MS2, TOTAL SAMPLE AND BY YEAR

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	16.56	13.29	15.04	14.71	20.04	18.58
	s.d.	5.65	5.14	6.12	5.16	3.74	5.33
GIRLS	n	102	13	29	14	27	19
	mean	16.58	14.92	16.59	15.00	16.78	18.58
	s.d.	5.68	6.75	5.92	6.29	4.75	5.16
t		-0.03	-0.71	-0.93	-0.13	2.74	0.00
Prob. level (t)		n.s.	n.s.	n.s.	n.s.	.01**	n.s.
F		2.45	0.69	0.05	6.85[1]	9.13	2.89
Prob. level (F)		n.s.	n.s.	n.s.	n.s.	.004***	n.s.

KEY *** $p \leq .001$ F level refers to analysis of variance with age and AH4 covaried. 1. Please see p. 222

** $p \leq .01$ Positive values of t indicate boys' superiority, negative values girls'.

TABLE 33: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON MS3. TOTAL SAMPLE AND BY YEAR

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	4.44	3.93	4.25	3.64	4.83	5.58
	s.d.	1.90	1.59	1.94	2.06	1.71	1.88
GIRLS	n	102	13	29	14	27	19
	mean	3.87	3.54	4.31	3.86	3.59	3.84
	s.d.	1.73	1.76	1.83	1.88	1.78	1.38
t		2.15	0.60	-0.12	-0.29	2.54	2.77
Prob.level (t)		.03*	n.s.	n.s.	n.s.	.01**	.01**
F		10.51	0.27	0.42	1.97	6.63	19.46
Prob. level (F)		.002**	n.s.	n.s.	n.s.	.01**	.001***

KEY *** $p \leq .001$ ** $p \leq .01$ * $p \leq .05$ Positive values of t indicate boys' superiority, negative values girls'. F level refers to analysis of variance with age and AH4 covaried.

TABLE 34: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON MS4, TOTAL SAMPLE AND BY SEX

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	4.53	3.71	3.92	4.71	5.17	5.25
	s.d.	2.37	2.61	2.34	2.06	1.90	2.45
GIRLS	n	102	13	29	14	27	19
	mean	4.15	3.85	3.97	4.43	3.93	4.74
	s.d.	2.27	2.44	2.27	2.34	2.43	1.97
t		1.17	-0.14	-0.12	0.35	2.04	0.61
Prob. level (t)		n.s.	n.s.	n.s.	n.s.	.05*	n.s.
F		3.31	0.03	0.52	0.58	4.29	0.60
Prob. level (F)		n.s.	n.s.	n.s.	n.s.	.05*	n.s.

KEY * $p \leq .05$. Positive t values indicate boys' superiority, negative values girls'.

F level refers to analysis of variance with age and AH4 covaried.

MS5. Significant sex differences appeared for the total sample and in Years 4 and 5. Once again these were in favour of boys and remained after age and AH4 had been covaried out (see Appendix VII, pp 525 - 27).

Thus of the five sub-tests, three showed sex differences for the total sample and two showed no sex differences for the total sample. None of the five showed significant sex differences for the first three year groups. Year 4 showed the most marked sex differences - significant differences, in favour of boys, being shown on all five sub-tests. Year 5 showed significant sex differences on two sub-tests.

Note from Table 32, page 219. Three of the analyses of variance for the third year are difficult to interpret. In this, the first case, the t-test shows a non-significant advantage for girls. Boys are older in this year but girls score higher on g. As both g and age affect test scores, it will be seen that the two independent variables tend to act in different directions. The relevant analysis of variance (Appendix VII, page 517) shows a greater mean square for age than for AH4. This means that the likely direction of the main effect for sex is in favour of girls. The only way of establishing this would be to covary the two independent variables simultaneously, but as their underlying population parameters probably differ this would be by no means straightforward. On the advice of Dr. Pilliner of the Godfery Thomson Unit for Academic Assessment, University of Edinburgh, it was decided to treat the sex difference as non-significant.

TABLE 35: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON MS5, TOTAL SAMPLE AND BY YEAR

	TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS n	88	14	24	14	24	12
mean	3.65	2.43	3.00	2.93	4.46	5.58
s.d.	2.77	2.17	2.93	2.30	3.04	1.62
GIRLS n	102	13	29	14	27	19
mean	2.53	1.61	2.69	2.29	2.48	3.16
s.d.	2.08	1.70	1.63	2.27	2.21	2.48
t	3.11	1.07	0.46	0.74	2.63	3.29
Prob. level (t)	.002**	n.s.	n.s.	n.s.	.01**	.003
F	18.91	0.43	2.46	4.68[1]	8.09	13.54
Prob. level (F)	.001***	n.s.	n.s.	n.s.	.007**	.001***

KEY *** $p \leq .001$ ** $p \leq .01$

F level refers to analysis of variance with age and AH4 covaried.

Positive values of t indicate boys' superiority.

1. Please see note on page 224.

Table 36 shows sex differences for the Moray House Space Test total (TOTMS). The appropriate analyses of variance can be found in Appendix VII, pages 528-530 . The results on this mirror, of course, those of its five subtests. They show significant sex differences in favour of boys after age and AH4 have been covaried for:

(i) the total sample

(ii) Years 4 and 5.

No significant sex differences are shown for the first three year groups.

The Quasi-spatial Tests

As well as the standard space test, the Moray House space test just discussed, project two contained two quasi-spatial tests. The first of these was MAP 2 which was a test of visualization. As Table 16

Note 1. from Table 35. Once again the directional effect for the F value associated with sex is not easy to determine (See Appendix VII, p. 526). The directional advantage is in favour of the boys this time, but the F value for covarying AH4 is very small indeed, being significant at the .99 level. Thus the major covariance effect is probably for age, suggesting an advantage for girls. Once again on the advice of Dr. Pilliner the sex difference is treated as non- significant.

TABLE 36: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON THE TOTAL MORAY HOUSE SPACE TEST, TOTAL SAMPLE

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	36.43	28.86	32.75	32.50	42.21	43.67
	s.d.	13.45	11.10	14.76	12.73	9.90	12.23
GIRLS	n	102	13	29	14	27	19
	mean	33.98	28.54	34.59	32.57	33.63	38.32
	s.d.	11.62	13.78	11.97	11.30	10.92	10.03
t		1.33	0.07	-0.49	-0.02	3.27	1.27
Prob. level(t)		n.s.	n.s.	n.s.	n.s.	.002**	n.s.
F		10.30	0.03	0.68	7.44[1]	13.68	9.39
Prob. level (F)		.002**	n.s.	n.s.	n.s.	.001***	.005**

KEY *** $p \leqq .001$ ** $p \leq .01$ F level refers to analysis of variance with age and AH4 covaried.

Positive values of t indicate boys' superiority, negative values girls' 1. See note on page 226.

showed the partial correlation of MAP 2 with the total MS score, after AH4 was partialled out, was .3665. Thus it might have been expected to show the same tendencies with respect to sex differences as MS did. Table 37 shows that this expectation is confirmed, significant sex differences are shown both for the total sample and for years 4 and 5. All these are in favour of boys and remain after AH4 has been covaried (see Appendix VII, pp 531 - 533).

The second quasi-spatial test was COMPLACE 2 which was a test of location of places in the vicinity of the school. As Table 14 showed this test failed to correlate significantly with any other measures used in project two with the exception of MS4. It is not therefore surprising to note from Table 38 that it does not conform with MAP 2 or with the Moray House Space test with regard to sex differences.

Note 1 from Table 36. This is the third ambiguous value of F, referred to on page 222. Here once more the advantage would appear to be in favour of girls as the directional advantage lies with them and age is a more powerful covariate than AH4 (see Appendix VII, p 529), which would act to reinforce the girls' superiority on raw score. As before, the sex difference is treated on the advice of Dr. Pilliner as non-significant.

TABLE 37: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON MAP 2, TOTAL SAMPLE AND BY YEAR

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	10.17	10.21	8.87	8.71	11.42	11.92
	s.d.	3.26	3.78	3.27	3.12	2.45	2.75
GIRLS	n	102	13	29	14	27	19
	mean	9.75	8.69	8.76	10.86	9.59	11.42
	s.d.	3.38	2.63	3.21	2.98	4.12	2.46
t		0.86	1.23	0.13	-1.86	1.94	0.51
Prob. level (t)		n.s.	n.s.	n.s.	n.s.	n.s. (.06)	n.s.
F		4.94	0.47	0.74	0.47	3.54	5.21
Prob. level (F)		.03*	n.s.	n.s.	n.s.	n.s. (.06)	.03*

KEY * $p \leq .05$ Positive values of t indicate boys' superiority, negative values girls'.

F level refers to analysis of variance with age and AH4 covaried.

TABLE 38: PROJECT TWO: SUMMARY OF SEX DIFFERENCES ON COMPLACE 2, TOTAL AND BY SEX

		TOTAL	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
BOYS	n	88	14	24	14	24	12
	mean	9.31	9.07	9.42	9.93	9.08	9.08
	s.d.	1.84	3.12	1.32	1.38	1.77	1.50
GIRLS	n	102	13	29	14	27	19
	mean	8.32	8.92	7.55	8.50	8.33	8.95
	s.d.	1.94	1.50	1.96	1.99	2.07	1.71
t		3.57	0.16	4.13	2.20	1.39	0.82
Prob. level (t)		.001***	n.s.	.001***	.05*	n.s.	n.s.
F		14.89	0.67	16.68	7.37	1.78	0.13
Prob. level (F)		.001***	n.s.	.001***	.01*	n.s.	n.s.

KEY *** $p \leq .001$ * $p \leq .05$ Positive values of t indicate boys' superiority

F level refers to analysis of variance with age and AH4 covaried.

Sex differences are shown on the younger years rather than the older. It is possible that these may be ascribed to the fact that younger girls are allowed less freedom to move around than boys are, whereas after year 3 they are probably allowed equal freedom. The relevant analysis of variance can be found on pp 534 - 536, Appendix VII.

In summary then, the spatial sub-tests and MAP 2 tend to show sex differences in favour of boys on raw scores, once AH4 and age are covaried out. These tend to be shown for the total sample and for the two older age groups. They are not shown for the younger age groups. This latter finding is similar to the findings of project one which did not show sex differences for a primary school age group on a battery of quasi-spatial tests.

B Coaching Investigation

One of the aims of this study was to investigate the effect of coaching on performance at spatial tests. Accordingly the second and fourth year groups were split into two. In each year, one group acted as an experimental group, the other as a control. Details of the procedure can be found in Chapter 3 and Appendix V. Briefly, the experimental group did the Moray House spatial test, received 50 minutes coaching and then took the test again two weeks later while the control group took the test twice at a two week interval but received no coaching.

General results on coaching will be dealt with in Chapter 7 but in this chapter I will deal with results pertaining to sex differences. On neither group were there significant differences on age or AH4 scores, so that analyses of covariance were not considered necessary to supplement the t-tests[1].

The experimental group showed no significant sex differences, either before or after the coaching. The boys were marginally better on total score before coaching and the girls after.

1. For the coaching group, ages were: boys, mean = 14.79, s.d. = 1.04; girls, mean = 14.87, s.d. = 1.03;
AH4 scores were: boys, mean = 28.48, s.d. = 11.62; girls, mean = 30.58, s.d. = 10.83.
For the control group ages were: boys, mean = 14.89, s.d. = 1.14; girls, mean = 14.81, s.d. = 1.15;
AH4 scores were: boys, mean = 31.79, s.d. = 10.37, girls, mean = 33.10, s.d. = 8.58

TABLE 39A PROJECT TWO: SEX DIFFERENCES ON COACHING SAMPLE, (BOYS, n = 29, GIRLS, n = 26)

	MS1		MS2		MS3		MS4		MS5		TOTMS	
BOYS	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.	Bef.	Aft.
mean	6.52	8.21	16.00	18.34	4.10	4.86	4.34	5.31	3.24	5.21	34.21	41.93
s.d.	3.61	3.70	5.71	5.02	1.70	1.75	2.29	1.85	3.05	2.55	13.13	12.31
GIRLS												
mean	6.62	9.50	16.27	18.27	4.04	4.81	4.23	5.46	2.35	4.19	33.50	42.23
s.d.	3.15	2.60	6.07	6.07	1.80	1.98	2.35	1.84	1.74	3.12	11.87	13.01
t	-0.11	-1.48	-0.17	0.05	0.14	0.11	0.18	- 0.30	1.31	1.32	0.21	-0.09
Prob.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY Bef. before coaching Aft. after coaching

Positive values of t indicate boys' superiority, negative values girls'.

Table 39A shows these small sex differences both before and after coaching. The control group, however, shows larger and significant sex differences on both sessions (Table 39B). In both cases boys performed better than girls but on the second session, their superiority was less marked. Whereas five out of six comparisons on the first session showed significant superiority for boys, only two of the six comparisons of the second session showed significant superiority for boys. Further the level of significance dropped on the total score from .01 to .055.

It would seem that girls gained relatively more from experience. Table 39C compares the actual gains over the two sessions for the sexes and it will be seen that five out of six comparisons are in favour of girls, one (MS1) significantly so. Moreover although the TOTAL Moray House Space Test gain is not significantly greater for girls than boys, it is clearly higher, (7.07 compared with 4.70).

There are two implications to be drawn from these results. In the first instance the instability of sex differences in small samples is further confirmed. This study has shown sex differences on a spatial test for one sample of 49 children aged 14+ years. Another sample of 55

TABLE 39B: PROJECT TWO: SEX DIFFERENCES ON CONTROL SAMPLE (boys, n = 19, girls, n = 30)

	MS1		MS2		MS3		MS4		MS5		TOTMS	
BOYS	Ist	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
mean	9.32	9.37	19.89	21.37	5.21	5.74	4.84	6.37	4.47	5.21	43.74	48.05
s.d.	3.21	2.77	4.69	4.35	1.87	1.79	2.09	0.89	2.95	2.88	12.34	10.68
GIRLS												
mean	7.23	8.63	17.03	19.27	3.90	5.07	3.70	4.83	2.80	3.93	34.67	41.73
s.d.	3.70	3.38	4,69	4.74	1.88	1.60	2.32	2.12	2.06	2.43	11.15	11.14
t	2.02	0.79	2.08	1.56	2.38	1.37	1.74	2.99	2.34	1.67	2.60	1.96
Prob. level	.05*	n.s.	.04*	n.s.	.02*	n.s.	n.s.	.004***	.02*	n.s.	.01**	.055*

KEY *** p ≤ .001 ** p ≤ .01 * p ≤ .05 1st first administration 2nd second administration

Positive values t indicate boys' superiority

TABLE 39C: PROJECT TWO: SEX DIFFERENCES ON GAINS BETWEEN FIRST AND SECOND SITTING OF MS TEST (Boys, n = 19; girls, n = 30) CONTROL GROUP

	MS1	MS2	MS3	MS4	MS5	TOTMS
BOYS mean	0.53	1.57	0.53	1.53	0.74	4.32
s.d.	1.27	2.34	1.39	1.68	1.76	4.70
GIRLS mean	1.40	2.33	1.17	1.13	1.13	7.07
s.d.	3.37	3.13	1.58	1.55	1.89	6.95
t	-1.98	-0.97	-1.49	0.82	-0.75	-1.65
Prob. level	.05*	n.s.	n.s.	n.s.	n.s.	n.s.

KEY * $p \leq .05$ All t values indicate difference in favour of girls, except for MS4.

children drawn from the same school, from parallel forms, the same age and tested at the same period in time displayed no sex differences.

Secondly there is an indication that practice reduced sex differences on the control sample. On the first session significant sex differences were shown on five out of six comparisons, on the second on only two of six. Furthermore sex differences on total scores fell from a probability level of .01 to a level slightly below that conventionality regarded as significant (.055). That practice served to reduce sex differences can be interpreted in two ways. It may have been that the girls were more motivated than the boys, or it may have been that the girls who had no experience of woodwork and technical drawing benefited more the second time because the stimuli were relatively less unfamiliar to them this time round. It is not possible to test the second of these hypotheses because at this age level all boys had done at least one year's woodwork and technical drawing and none of the girls had had any experience of these classes. However it is possible to test the first hypothesis by looking at the answers to the question 'How much have you enjoyed this spatial test?'.[1] Answers revealed that the boys indicated signficantly more enjoyment (boys, mean 1.89, s.d. 0.74; girls, mean 2.77, s.d. 1.08; t 3.39. $p < .002$, higher answers indicating lower enjoyment).

These results, though hardly conclusive, suggest that for the one sample, experience benefited girls rather more than boys. I will

1. Answered at the end of the second session.

return to this in the discussion at the end of the chapter.

C. Correlation Matrices

The correlation matrices for the two sexes on the tests of project two, are set out in Table 40. They have been corrected to two decimal places for clarity of comparison. As Table 40 shows there were no major differences in the correlation matrices for the sexes, with the exception of the intercorrelations with MS5. This is the test that showed the most pronounced sex differences. It will be noticed that all of its intercorrelations with the other spatial tests and MAP2 are lower for girls than they are for boys (six out of six comparisons - two at the .05 level, two at the .10 level and two non-significantly). I shall return to this point in the discussion at the end of this chapter.

D Factor Analyses and Partial Correlation

In chapter four various factor analytic techniques were discussed in presenting the data for the total sample in project two. It will be remembered that the best fit to the data appeared to be a classical factor analysis, using an oblique rotation. The same technique was therefore used for the two sexes treated separately. The technique

TABLE 40: PROJECT TWO: INTERCORRELATIONS OF NINE MEASURES FOR TOTAL SAMPLE, BY SEX (PEARSON'S CORRELATION COEFFICIENTS, Boys = 88, girls = 102[1], girls' correlations in boxes).

	MS2	MS3	MS4	MS5	TOTMS	COMP2	MAP2	AH4
MS1	.71***	.55***	.33***	.60***	.85***	.02	.38***	.45***
	.62***	.55***	.39***	.26***	.83***	.05	.42***	.39***
MS2		.58***	.49***	.63***	.92***	.00	.50***	.52***
		.44***	.41***	.38***	.91***	.11	.39***	.48***
MS3			.35***	.49***	.71***	-.04	.23*	.36***
			.34***	.18	.64***	.03	.26**	.34***
MS4				.44***	.61***	.13	.33***	.19
				.30***	.62**	.23*	.32***	.26**
MS5					.79***	.06	.45***	.35***
					.53***	-.03	.31***	.31***
TOTMS						.02	.50***	.50***
						.12	.48***	.51***
COMP2							.09	.01
							.22*	.25**
MAP2								.34***
								.52***

KEY *** $p \leq .001$ ** $p \leq .01$ * $p \leq .05$

COMP2 COMPLACE 2 1. Please see note on next page.

made, as for the total sample, the following three subjective assumptions:

(i) that there was unique variance associated with each variable

(ii) that the two factors were obliquely correlated

(iii) that the two factors while correlated, were not heavily correlated.

The reasons for these three assumptions will be found in Chapter 4, pp 168 - 174 . Table 41 sets out the results of this analysis for the sexes. It will be seen that for both sexes the first factor, loading as it does on AH4, is a general factor. The second factor is not so clear-cut for either sex and accounts for comparatively little of the variance[1]. In the case of the boys, the second factor loads, though

1. I did perform various other factor analyses, including orthogonal rotations. None produced a more clear-cut second factor for either sex. All analyses reflected the low intercorrelation, for the girls after AH4 is partialled out, of MS3 and MS5, the two tests showing the greatest sex differentiation. That is no analysis produced a second factor loading on both these tests for the girls.

Note 1 from page 237. As there were more girls than boys, the correlation coefficients for the girls have been extrapolated, using the tables of r in Lewis (1967).

TABLE 41: PROJECT TWO: FACTOR ANALYSES OF NINE TESTS BY SEX.
(CLASSICAL FACTOR ANALYSIS WITH ITERATIONS AND OBLIQUE ROTATIONS OF THE AXES) (boys = 88, girls = 102)

	BOYS		GIRLS	
	FACTOR I	FACTOR II	FACTOR I	FACTOR II
MS1	.916	-.165	.850	-.291
MS2	.885	.081	.840	.011
MS3	.795	-.144	.731	-.482
MS4	.257	.870	.607	.153
MS5	.733	.192	.413	.753
TOTMS	.946	.152	.987	.003
COMPLACE 2	-.019	.159	.139	.054
MAP 2	.448	.162	.491	.111
AH4	.538	-.056	.524	.074

$r_{\text{Factor I/II}} = 0.270$

$r_{\text{Factor I/II}} = 0.139$

not very heavily on all the spatial and quasi-spatial tests except MS1 and MS3 and, as would be expected for a spatial factor, does not load on AH4. For the girls the second factor loads less consistently on the spatial and the quasi-spatial tests and there is a heavy negative loading on MS3. It does not load on AH4 and therefore may be regarded as a spatial factor.

The partial correlation of the tests, after AH4 is partialled out is shown in Table 42 for the two sexes. Two points emerge. Firstly in twenty-one possible comparisons of the coefficients, seventeen are lower for girls (the three exceptions being with MS1 which loads positively only on the first factor for both sexes). Although some of these differences are small, their directional consistency conforms with project one as well as other studies which show lower intercorrelations for spatial tests for girls than for boys. (For example Yen, 1975B). Secondly the results of the factor analyses are confirmed; the two tests showing the greatest intersex differences (MS3 and MS5) have a near-zero correlation for the girls after AH4 is partialled out. That is, for the girls the evidence for a spatial factor is less clear than it is for boys (see also Vernon, 1961, 1972).

TABLE 42: PROJECT TWO: PARTIAL CORRELATION OF SEVEN MEASURES[1] CONTROLLING FOR AH4, BY SEX (boys = 88, girls = 102)[2] PEARSON'S CORRELATION COEFFICIENTS[3] (Girls' correlations in boxes)

	MS2	MS3	MS4	MS5	TOTMS	MAP 2
MS1	.63***	.47***	.27**	.53***	.81***	.28**
	.55***	.49***	.33***	.17	.80***	.30**
MS2		.50***	.46***	.56***	.89***	.40**
		.35***	.34***	.29**	.88***	.21*
MS3			.31**	.42***	.65***	.12
			.29**	.09	.59***	.12
MS4				.40***	.61***	.28***
				.24	.59***	.23*
MS5					.75***	.37***
					.46***	.20*
TOTMS						.41***
						.31**

KEY *** $p \leq .001$ ** $p \leq .01$ * $p \leq .05$

1. As there were more girls than boys, the girls' correlations have been extrapolated using the tables of r in Lewis (1967)
2. COMPLACE 2 has been omitted in view of its non-significant correlation for the total sample, before AH4 is partialled out.
3. Correlation coeffecients have been corrected to two decimal places for clarity of comparison.

These two points have important implications. They suggest, for example, that girls perform less consistently at spatial tests than boys do. They also suggest that a valid test of spatial ability for boys may be less so for girls, and vice versa. For example, referring to Table 41, MS4 is more heavily loaded with the spatial factor for boys than for girls.- it is in fact the test with the heaviest loading for boys. In contrast MS5 is most heavily loaded with spatial ability for girls. This leads to a further question: is there a unique spatial ability? I shall return to these considerations in the discussion at the end of this chapter. For the moment, however, I will examine my results to see, referring to the last point, whether there is any evidence for the two components of spatial ability suggested by Yen (1975B), orientation and visualization, for the sexes considered separately.

E Orientation and Visualization

When discussing the evidence for these two components of spatial ability for the total sample (Chapter 4, p 176-178) I suggested that MS1 and MS3 could be regarded as tests of orientation and MS5 and MAP 2 as tests of visualization, using the definitions given by Yen (1975B). Table 43A and 43B show the intercorrelations between these two measures for the sexes; figures in brackets are the correlations

TABLE 43A: PROJECT TWO: · INTERCORRELATIONS OF TESTS OF SPATIAL ORIENTATION AND SPATIAL VISUALIZATION

BOYS, (n = 88)

		ORIENTATION	VISUALIZATION	
		MS3	MS5	MAP2
ORIENTATION	MS1	.5537***(.4703***)	.5981*** (.5274***)	.3847*** (.2763**)
	MS3		.4867*** (.4155***)	.2291* (.1218)
VISUALIZATION	MS5			.4483*** (.3744***)
	MAP 2			

KEY

*** $p \leqslant .001$

** $p \leqslant .01$

* $p \leqslant .05$

Brackets show partial correlation coefficients after AH4 has been partialled out.

TABLE 43B: PROJECT TWO: INTERCORRELATION OF TESTS OF SPATIAL ORIENTATION AND SPATIAL VISUALIZATION

GIRLS (n = 102)

		ORIENTATION	VISUALIZATION	
		MS3	MS5	MAP2
ORIENTATION	MS1	.5307*** (.4688***)	.2365** (.1466)	.4030*** (.2778**)
	MS3		.1593 (.0737)	.2381* (.1015)
VISUALIZATION	MS5			.2939*** (.1848*)
	MAP 2			

KEY

*** $p \leq .001$

** $p \leq .01$

* $p \leq .05$

Brackets show partial correlation coefficients after AH4 has been partialled out.

after AH4 has been partialled out.

In general, as for the total sample, there is some evidence that the intercorrelation for the two tests of orientation are higher than their correlations with the other two tests for both boys and girls. In the case of visualization the correlation coefficients between the two supposed measures, MS5 and MAP 2 are not of a higher order than they are with the other variables.

Thus there is no apparent difference between the sexes with respect to evidence for the two cited components of spatial ability and it does not seem, in particular, that the non-correlation for the girls of the MS3 and MS5 tests can be attributed to the fact that MS3 is a test of orientation and MS5 of visualization.

F Two and Three Dimensional Tests

The two tests that most differentiate between the sexes are MS5 and MS3. These are both three-dimensional tests but so is MS4 which shows the least indication amongst the spatial tests of sexual differentiation. Thus there is no clear cut distinction to be made between two and three dimensional tests in terms of comparative ease of solution for the two sexes.

Discussion

In this discussion, I would like to follow the sequence I used in presenting the results on sex differences in this chapter. That is I shall first consider sex differences on raw scores, then on correlation matrices and factor analyses and finally on possible components of spatial ability. This study is not only concerned with documenting sex differences in my own sample, but also in relating these to the literature and, perhaps more fundamentally, in seeing how the results bear on theories proposed to account for sex differences in adults on tasks of a spatial nature. Thus in this discussion, points will be raised which will be developed in chapters 6, 7 and 9 which deal with respectively, developmental trends in sex differences in this area, variables affecting the differences and sex differences in cognitive style. The last chapter will attempt to synthesize the preceding ones and to draw some conclusions about the aetiology of sex differences in this area.

Considering the results on sex differences on raw scores, I think four points emerge. I shall deal with these in turn. They are:

(i) In general, there were no sex differences on the quasi-spatial tests used in project one, once *g* had been partialled out. (Tables 19-23)

(ii) Sex differences on psychometric tests appear unstable for younger children.

(iii) On the spatial tests of the second project, sex differences in favour of boys were shown, once *g* had been partialled out, for the total sample. This difference was not significant for the three younger age groups (Tables 31 - 37).

(iv) Girls appeared to benefit relatively more from experience.

(i) As I reported in the first two chapters, sex differences in spatial ability have not been consistently reported for younger (pre-adolescent) children. I now suggest that this may be due to one or both of two possible causes. In the first instance tests used with this age group may not be adequate measures of spatial ability and secondly such sex differences in spatial ability may not exist for younger children,

My own results suggest that the quasi-spatial tests I used were not adequate measures of spatial ability. There are two strands of evidence for this. If, for the moment, we take spatial ability or abilities to be measured adequately by the standardised test I used in the second project, it was shown that this did not correlate well with the quasi-spatial tests used in project one for the longitudinal sample (Table 14B). The quasi-spatial tests used tended in fact to correlate more highly with the tests of general intelligence (AH4). Secondly the correlational data did not show a good fit with the criteria proposed by Vernon, for evidence of an ability (Chapter 4).

As the quasi-spatial tests used in project one were with the exception of MAP1, representative samples of tests reported in the literature it would seem that the first reason suggested can account, in part, in any event for the inconsistency of results. Sex differences may have been due to chance variations of *g* in the samples tested; and as I shall discuss in the next point these appear to be fairly unstable.

The second reason for the inconsistent results may be that no sex differences exist in younger children in spatial ability or abilities. Taking the Moray House Space test and its subtests as measures of spatial ability or abilities, it is clear that sex differences in the second project only appeared at age 14+. I shall return to discuss this in detail in the next chapter but should note that this fits with the results of Karnovsky (1975) who reported sex differences as appearing at grade 7 on a standard spatial test and with the work of Wolf (1971) who used a quasi-spatial test (an embedded figure test). Covarying out intelligence (on the Lorge-Thorndyke scale, Wolf, 1971) he found no sex differences with a sample of 180 children from grades 1 to 6. Similarly Nash (1974) found sex differences on the DAT space relations test at 14 years but not at 11 years. Thus it would seem that both the reasons cited can account for the lack of sex differences in spatial ability reported for younger children.

(ii) That sex differences on psychometric tests tend to be unstable in children has been ably documented by Maccoby and Jacklin (1974) and Fairweather (1976). My own study shows four instances of this. The first is the difference on the tests of *g*. It will be remembered that the boys of the first project tended to score higher at both measures of *g* (subtests of the WISC) and significantly higher at one; whereas girls in the second project scored significantly higher at the measure of *g* I used for the older children (AH4). These two samples were drawn from the same geographic area and were reportedly similar, though not identical, in class origins.

Some studies do show that boys perform better at the WISC in the primary school age groups. For example, Jones (1962) showed this with 240 London school children aged 9 to 11 years. However in general IQ tests are not reported as showing sex differences for children, having been designed to produce minimal sex differentiation. (Maccoby and Jacklin, 1974). But clearly small samples will tend to show chance variations and indeed Garner et al. (1971) in a study I have already referred to, showed that sex differences on the WISC changed as English county borders were crossed.

With reference to the better performance of the girls in the secondary sample, the literature would appear to suggest that as children grew older, sex differences in IQ in favour of boys tend to increase, (e.g. Campbell, 1974, Bradway and Thompson, 1962). I shall return to this in Chapter 9. So, in this context, it is surprising to find significant sex differences in favour of girls for the oldest age group tested (Year 5).

I think this can be best understood in terms of a slight bias in sampling at this stage. The children were tested in tutorial sets but inevitably there were absences. When I first tested the fifth year group, only 22 pupils arrived. The rest were said to be at optional outdoor activities. When I reported this to the deputy head teacher, another time was set aside for this age group. I think that those who elected to attend rather than find some other activity more pressing[1], were those girls who were more academically motivated. In general I think two conclusions can be drawn about the inconsistency in sex differences on g. Firstly, small samples are bound to generate chance differences and secondly, that even in carefully regulated studies, an element of self-selection affects the sampling.

A second element of instability in sex differences was shown by the longitudinal sample. Table 24 shows that there were significant differences for these 22 children, when they were tested in the primary school on MAP1 and COMPLACE1 ($p \leq .01$ and $p \leq .05$ respectively). When the children performed very similar tests the following year, there were no significant differences on MAP2, although the boys did

1. Of course officially my study had been given priority, but some boys were understood to 'have gone on messages for teachers, or to the dentist or to be doing prefect duties'.

directionally better and the girls did directionally better at COMPLACE2.

Thirdly sex differences were shown in the drawing component of the Keogh tasks for primary four, but not for primary three.

Finally, yet another inconsistency was shown in my study when sex differences were examined for the Moray House Space Test total and its subtests for the two mixed second and fourth year samples that comprised the control, and experimental groups of the coaching exercises. It will be remembered that although drawn from parallel forms and the same age, the control group showed sex differences while the experimental group did not.

It must be concluded that stable sex differences on psychometric tests are not characteristic of small samples. For example Immergluck and Mearini (1969) investigating responses to embedded figures and reversable figures with 120 children aged from nine to thirteen years reported that the ontogenic course of sex differences followed a 'zigzagging and overlapping pattern rather than a unidirectional path' (p. 210). What is particularly important in this regard is that so many studies on which sex differences are reported, deal with comparatively small samples of children (e.g. Keogh and Ryan, 1971, n = 44; Saarni, 1973, n = 64).

(iii) A third point emerging from the raw scores is that sex differences were revealed on the spatial and quasi-spatial tests of project two for the total sample. It should be borne in mind however that such differences were not shown for two of the spatial subtests of the Moray House Space test and that they were not shown for the three younger age groups nor for the coaching subsample).

Nevertheless, there is no doubt that substantial sex differences were revealed for the total sample on the Moray House Space test, MAP 2 and COMPLACE 2 when the measure of *g* was partialled out. That these tests were sampling a spatial factor was investigated by means of factor and correlational analyses. These showed that while some of the variance was shared with the test of general intelligence, after this was partialled out, high and significant intercorrelations remained[1] (Tables 16 and 42). This was taken

1. With the exception of the quasi-spatial test COMPLACE 2 (see Table 16).

as indicative of at least one other factor. However the detailed factor analyses (Tables 15A, 15B, 15C and 41) did not reveal a single clear spatial factor[1]. I think it must be concluded that while boys scored significantly higher at nearly all the spatial tasks in the total sample, such an advantage could not be unambiguously explained by a unique spatial factor, even after *g* is partialled out. I shall return to this conclusion in the next section and to the fact that there were no sex differences in the first three years in the next chapter.

(iv) Girls appeared to benefit more from experience in the control group of the coaching exercise. Not too much should be made of this finding because of the small numbers involved and because a similar finding was not shown for the experimental group. As I mentioned before it is an open question whether further exposure to the spatial test would have served to reduce the sex differences shown by this group even more. It is, in any event an area that should be explored. It serves to suggest that at least some of the intersex differences

1. For example, even when the sexes are considered together (Table 15C) the second factor does not load on three of the MS subtests.

in performance at spatial tasks may be due to practice effects (see Chapter 2, pages 34 - 36).

The only similar study I can find is one in which the authors showed that practice aided EFT performance for women but not for men. This is a very small study done by Goldstein and Chance (1965) with 26 students. Maccoby and Jacklin remark of this study 'If the finding replicates, it will be strong evidence that sex differences in spatial ability are (in large degree) a product of differential training' (1974, p 129).

Returning to my own study, it is possible that the control girls showed rather more benefit from the second testing than the boys did, because the stimuli were less unfamiliar the second time than the first. The boys who all had technical drawing classes may have found them familiar the first time round. Why then did the experimental girls not show a similar relative gain? It could be speculated that the coaching sessions served to put them off the test. It certainly was my experience that these sessions, though ably conducted by an experienced teacher, were not really motivating unless one was interested in the subject matter in the first instance.

As I have mentioned before, there is no instrumental reason for adolescent school-children to perform to the fullest extent of their abilities at such test sessions. It was certainly my impression that in many instances only sporadic attention was being paid to the tutor and it is perhaps for this reason that, as Chapter 7 will show, coaching did not raise the scores much above merely repeating the test a second time around.

Aside from the four points just discussed emerging from the raw score results, two further points emerge from the correlational and factor analyses of both projects.

These are:

(v) Girls score less consistently at spatial tests than boys do.

(vi) Evidence for a spatial factor is less clear-cut for girls than for boys.

(v) Inspection of the correlation matrices for project one (Table 26) revealed that intercorrelations were lower on those quasi-spatial tests that had low *g* components for girls than they were for boys. Similar results were observed on the second project for the spatial tests and MAP2 (Table 42). These results accord well with those of Coie and Dorval (1973) and Yen (1975B)[1]. In Yen's large study of 2508 American school children, she showed that not only did girls score lower on spatial tests but also that their correlations and reliabilities were lower[2] (see Table 44). Further, a number of other studies have shown that inter-correlations on RFT and EFT are lower for women than for men and in some cases non-significant (see Siann, 1970 for a review of some of these studies and also Vernon, 1972).

This suggests either that clustering at the bottom of the scale is attentuating the girls' coefficients or that girls score less consistently. Inspection of the relevant means and s.d.s for Yen's sample (Table 44) and for my own projects (Tables 19-23 and 31-37) do not bear out the first suggestion. Girls' scores do not cluster around zero, not are their s.d.s substantially different from boys'.

1. It has been mentioned that some of these intercorrelational differences are not large, but that others are and that the direction of differences is pretty consistent (17 out of 21). The differences are largest on tests showing the greatest sex differences (page 240)
2. If the reliabilities were test-retest then it could be speculated that Yen's girls may also have shown relatively larger gains with practice.

It seems likely that they respond less consistently. This is particularly clear in the intercorrelations of MS3 and MS5 in the second project. These sub-tests while revealing the largest sex differences, do not intercorrelate significantly for girls (Tables 40 and 42).

If girls do score less consistently at spatial tests it would seem that their approach to these tests might be different to that of boys. They may see them as less similar. I will develop this suggestion in Chapter 9 but would mention that one of the more interesting results in project one was that the questions bearing on mobility correlated more positively for the boys with COMPLACE 1, COMPDIRE and MAP 1 than they did for the girls (see page 208). It seems to me that this result is more in accord with social explanations for sex differences on these tests than it is for biological. Is it possible that boys are slowly building up a consistent approach to tasks of a spatial nature to which they relate relevant experience while girls approach these tasks with the same skills with which they approach other psychometric tasks and with no specific <u>nous</u>? The data of project one would certainly appear to offer some support for this speculation. In this project both EFT and MAZES were more related to *g* scores for girls than they were for boys. Project two does

TABLE 44: INTERCORRELATION OF YEN'S SPATIAL TESTS BY SEX (taken from Yen, 1975, p. 290)

PMA is the Primary Mental Abilities Space Test
Form R, Form CC are two Form Board scores
PAPER is a Paper Folding test
SHEP R, SHEP CC are two 3D-orientation scores

	PMA	FORM	FORM	PAPER	SHEP	SHEP	Age
MALES[a]	R-W	R	CC		R	CC	
PMA R-W	1.000	0.256	0.471	0.535	0.538	0.575	0.022
FORM R		1.000	0.791	0.314	0.362	0.244	0.016
FORM CC			1.000	0.592	0.495	0.504	0.064
PAPER				1.000	0.490	0.566	0.086
SHEP R					1.000	0.924	-0.023
SHEP CC						1.000	0.029
Age							1.000
Reliability	-	0.819	0.817	0.824	0.784	0.783	-
Mean	39.596	72.205	13.544	11.825	33.328	13.044	15.954
SD	14.841	29.535	7.487	4.070	7.970	5.225	1.125
FEMALES[b]							
PMA R-W	1.000	0.205	0.448	0.487	0.401	0.498	-0.001
FORM R		1.000	0.734	0.245	0.371	0.221	-0.003
FORM CC			1.000	0.549	0.372	0.438	0.037
PAPER				1.000	0.289	0.439	0.059
SHEP R					1.000	0.850	-0.027

TABLE 44: (cont.)

FEMALES	PMA R-W	FORM R	FORM CC	PAPER	SHEP R	SHEP CC	Age
SHEP CC						1.000	0.027
Age							1.000
Reliability	-	0.808	0.725	0.797	0.704	0.651	-
Mean	32.303	57.598	10.214	10.978	26.206	8.806	15.925
SD	14.718	26.241	5.692	3.934	7.413	4.212	1.132

a N = 1025; missing observations are excluded.

b N = 1013: missing observations are excluded.

not reveal any data that directly supports this speculation, except the coaching data which as I suggested, may be interpreted as showing that once the girls are given more experience, their confidence may be higher. It must be admitted that these hypothese are speculative. However it does seem likely from point (v) (that girls are less consistent in performance at spatial tasks) and point (iv) (that girls are more positively affected by experience) that at least some of the intersex differences on spatial tasks are socially engendered.

(vi) I think I have already pointed out in some detail that my factor analytic results show less evidence for a spatial factor or factors for girls than they do for boys. Again this is consistent with the findings of others. Vernon writes (1972), page 372, 'Vernon (1961) found, on the basis of factor analyses with male and female army recruits, that the spatial ability factor is less clear-cut and less predicative of occupational skills in women'.

Thus it would seem that any attempt to define spatial ability must depend on the acceptance of at least five considerations:

(a) That such ability has probably more than one component.

(b) That these components do not clearly seem to fit into the categories suggested by French - spatial visualization and spatial orientation. Neither my data or that of Yen's (see pp 132 - 33) offered support for these two components.

(c) That these components do not seem to relate clearly to two or three dimensions. Neither my own data or those of Yen's or the study by Shepard and Metzler[1] (1971) would seem to support this dimensional categorisation.

(d) That the label 'spatial' applied to a test does not always guarantee that it is a valid measure of spatial ability or

1. Referred to on page 182

abilities. For example MS1 loads heavily on *g* for both sexes and appears not to load on any other factor. Similarly 'having a good sense of direction' which Hutt (1975B) regards as a spatial skill seems not to correlate at all with any of the spatial tests or sub-tests in project two.

(e) That a test may have differing components of *g* and spatial factors for the sexes. Thus MS4 has been shown to load heavily on the first factor for girls but not for boys and MS5 vice versa.

Finally in concluding this chapter on sex differences on spatial tasks, it is clear that these do exist on raw scores for older children and on correlational analyses for all age groups. What is not clear is that these differences can be ascribed to one single clear ability or even to more than one clear ability that is equally applicable to both sexes. I will return to these remarks in the last two chapters.

CHAPTER 6: DEVELOPMENTAL TRENDS

This chapter is concerned with developmental trends in sex differences on spatial tasks[1]. As I noted in my review of the literature, these are commonly reported to occur at the onset of adolescence in favour of males. While no large scale studies have been made with children less than 13 years of age, small scale studies using standard spatial tests do not show sex differences below this age (Wolf, 1971, Karnovsky 1974, Nash, 1974). My own study, as reported in the last chapter, showed sex differences only in the fourth year when children were aged about 15. The large scale normative data on the DAT space relations test only gives norms from grade 8 onwards (Bennett et al., 1968). As I noted in Table 1, these norms show that sex differences on the DAT tend to increase with age from grade 8 (13 - 14 years) to grade 12 (17+).

In this chapter, I will discuss the developmental pattern observed for sex differences on spatial tasks in the context of sex differences

1. In consideration of the conclusions drawn at the end of the last chapter, I shall refer in future to sex differences at spatial tasks rather than in spatial ability or abilities.

on other psychometric tests. I shall show that these too tend to widen with age in favour of males (Bennett et al, 1968, Bradway and Thompson, 1962). Before discussing the implications of this, however, I will report the relevant results from my own study. In most cases the data will be presented in the forms of graphs as the figures on which the graphs are based have already been summarised in the tables of the last two chapters.

Reporting Results - 5: Developmental Trends in Project One

As I noted in the last chapter, only four significant sex differences out of a possible thirty were reported in project one. However two of these occurred in Primary 7, suggesting that perhaps sex differentiation increased as children moved up the primary school. Closer examination of the longitudinal sample (79% of primary 7) showed however, that these sex differences were very unstable, disappearing when the children were retested in secondary school. This finding was related to the tenuous nature of sex differences in pre-adolescent children (pp 249 - 53). No other findings relevant to the subject of this chapter were made in analysing the results of project one.

Reporting Results - 5: Developmental Trends in Project Two

Figure 4 summarises the changes with year observed on the Moray House Space Test in project two. The relevant means from which the figure was drawn can be found in Table 36.

Looking at Figure 4, it will be seen that sex differences are small and inconsistent in direction in the first three years, but that by the fifth year boys are clearly better. It will also be noticed that boys' scores increase fairly consistently with year, except for a plateau effect from years 2 to 3. Girls, on the other hand, show a less consistent increase of scores with age. Their scores drop sharply from the second to the third year and do not regain the second year level even by the fourth year.

Figure 4 represents the sum of the raw scores on the spatial subtests of the Moray House Space test. Two points need to be borne in mind. Firstly all these subtest showed some *g* loading for both sexes (Table 41) and secondly girls were significantly higher in *g* as measured by the first part of AH4, in years 3 and 5. Thus figure 5 probably underestimates the advantage boys show on the spatial components of the MS score for these two years.

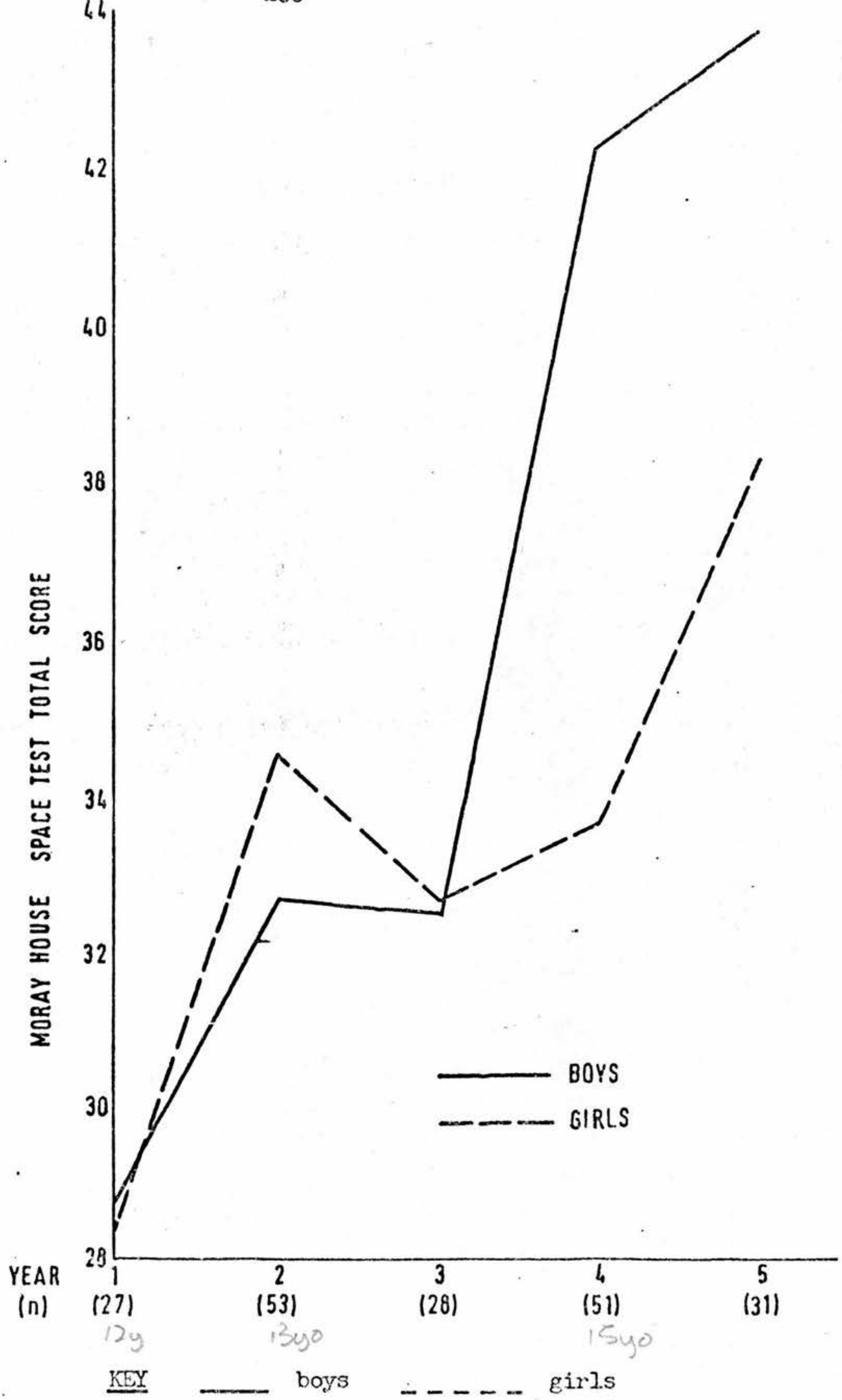

FIGURE 4: DEVELOPMENTAL TRENDS ON MS TOTAL. PROJECT TWO BY SEX

(BOYS, n = 88, GIRLS, n = 102)

Figure 5 shows the developmental trends on the MS total with the two subtests, showing the highest g loadings for both sexes subtracted. These tests were the same for both sexes - MS1 and MS2. Thus Figure 5 shows the developmental trends on the total of MS3, MS4 and MS5. It will be seen that the two points noted in discussing Figure 4 are shown again. Firstly the gap between the sexes is far wider at Year 5 than in the first years. Secondly whereas there is a clear relationship of scores with years for the boys no such consistency is observable for the girls.

Two quasi-spatial tests were used in project two. In Chapter 1 I showed that the first of these, COMPLACE 2 (the ability to point out directions) failed to correlate significantly with any of the tests used in the battery. Not surprisingly, the two points noted for the MS total were not shown for this test (see Figure 6). The advantage for the boys did not widen with age and while increases in girls' scores were inconsistent with year, so were boys'.

Figure 7 shows the change in scores on MAP 2 (the map visualization test) with year. Point 1, the tendency for boys' scores to widen with age is not seen, nor do girls's scores appear less consistent than

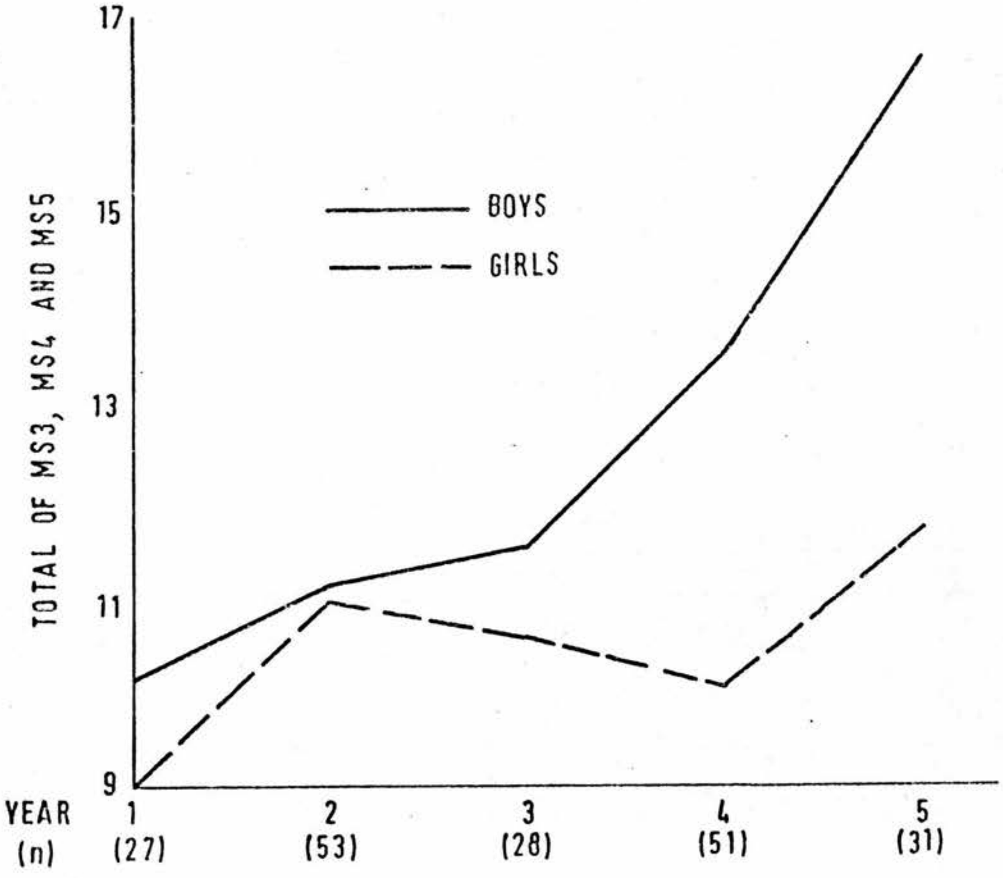

FIGURE 5: PROJECT TWO: DEVELOPMENTAL TRENDS ON MS3, MS4 AND MS5 TOTALLED BY SEX (BOYS: n = 88, GIRLS: n = 102)

boys' do.

Discussion

In considering the two points emerging from the developmental data on the Moray House spatial tests it must be borne in mind that the year samples were small, ranging from 27 (year 1) to 53 (year 2).

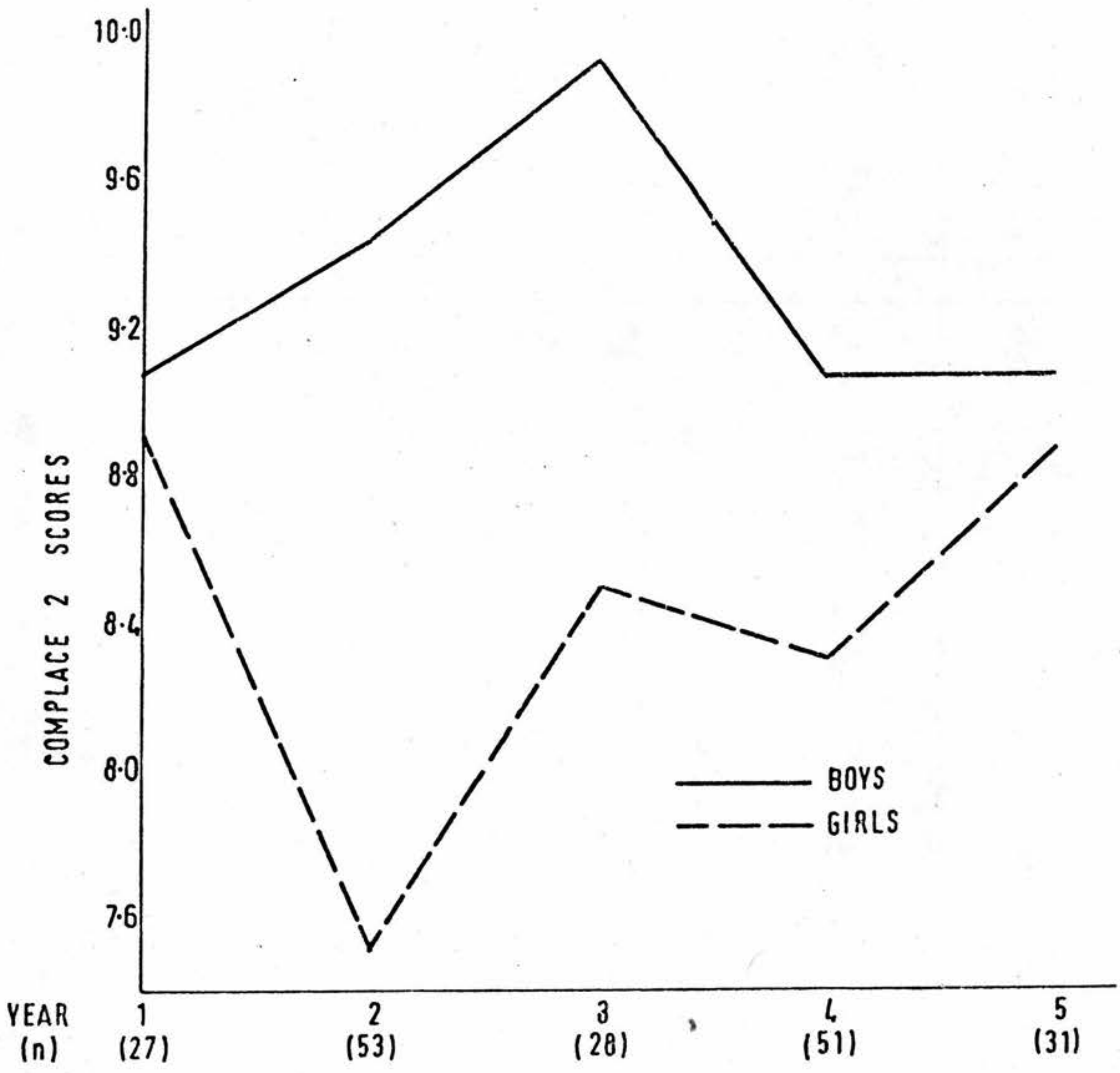

FIGURE 6: DEVELOPMENTAL TRENDS ON COMPLACE 2, PROJECT TWO, BY SEX

(BOYS: n = 88, GIRLS, n = 102)

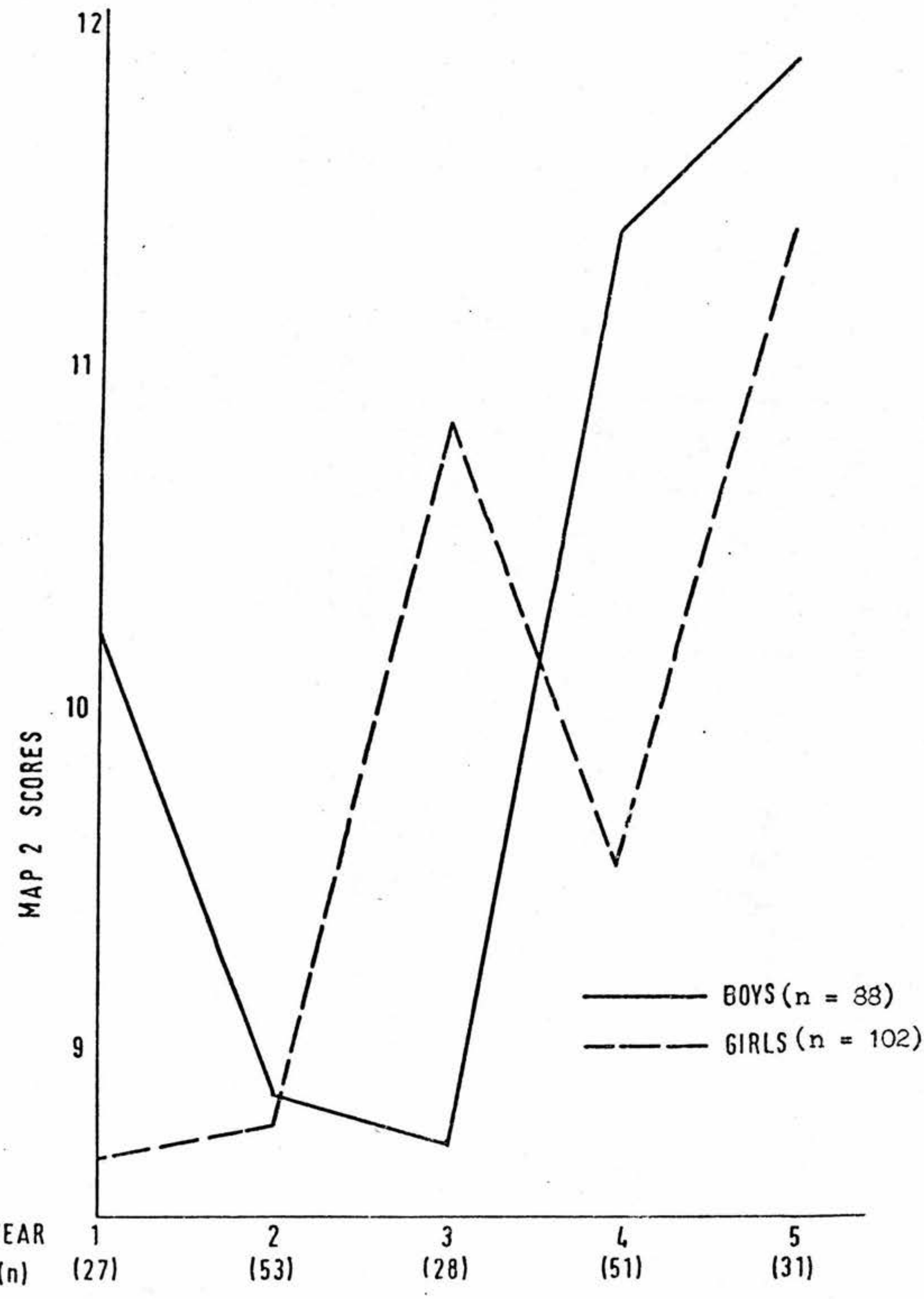

FIGURE 7: PROJECT TWO: DEVELOPMENTAL TRENDS ON MAP 2 BY SEX

However the two points do accord well with other studies as will be shown. These points were:

(i) Sex differences at spatial tasks appeared to increase with age (Figure 4 and 5).

(ii) The increase appears to be partially accounted for by the inconsistent increase in girls' scores with years (Figures 4 and 5).

(i) With reference to the first point, that sex differences on the Moray House Spatial test appeared to increase with age, it should be noted that the same effect is shown for the far larger samples used by Bennett et al., (1968) in the norms for the DAT space relation tests. I referred to this in the first chapter, where in Table 1 I tabulated the effect for one of Bennett's huge samples. This table only referred to one of the normative samples quoted but in fact precisely analagous effects are shown for three other equally large samples (Bennett et al., 1968, pp 3.8 - 3.25).

However Space Relations scores are not the only scores in the DAT battery that show widening sex differences with age. If scores on the standardised sum of the Verbal Reasoning test and the Numerical

Ability test are examined the same phenomenon emerges (pp 3.8 - 3.25, <u>ibid</u>). On this sum, referred to by Bennett et al., as (VR+NA) there are none or marginal sex differences on the four eighth grade samples, but by the 11th or 12th grade there are fairly substantial sex differences, all in favour of boys.

In Table 45, I have summarised the increasing sex differences shown for the DAT Space Relations test on the one hand, and the DAT verbal reasoning and Numeric ability on the other hand.[1] In this table I have subtracted the girls' 50th percentile score from the boys to indicate sex differences. The data from all four normative samples, quoted by Bennett et al. are given in the table. It will be seen that two of these cover the grades 8 to 12, and two the grades 8 to 11.

Table 45 shows that the two measures (VR+NA) and SR follow the same

1. Bennett et al, (1968) gives the data both separately for Verbal Reasoning and Numeric Ability and also for the standardised total (VR+NA). I should note that increase in sex differences with age in favour of boys is evident on the two tests individually as well as on the total (VR+NA) (pp 3.8 - 3.25, <u>ibid</u>).

TABLE 45: SEX DIFFERENCES ON VERBAL REASONING AND NUMERIC ABILITY (VR+NA) COMPARED WITH SEX DIFFERENCES ON SPACE RELATIONS (SR) ON NORMATIVE DATA FROM BENNETT ET AL. (1968)

	SAMPLE 1			SAMPLE 2			SAMPLE 3			SAMPLE 4		
	G.8	G.12	CHANGE	G.8	G.12	CHANGE	G.8	G.11	CHANGE	G.8	G.11	CHANGE
VR+NA	−1	4	5	0	4	4	0	3½	3½	0	4	4
SR	+2	+6	4	1½	5	3½	3	5½	2½	1½	4½	3

KEY G. = grade CHANGE = Difference at highest grade minus difference at lowest grade.

(Figures in the table represent the differences between the 50th percentile levels of boys and girls. Positive values represent differences in favour of males, the one negative a difference in favour of females. All n's are greater than 3850).

pattern with respect to sex differences. In each sample, there is a bigger gap between the sexes in the oldest age group than there is at the youngest. The changes are in fact fairly similar, the only difference between the two measures occurring at the grade 8 level where there is a difference in favour of the boys on SR but not on VR+NA.

An implication that can be drawn from Table 45 is that as children get older, boys tend to surpass girls on psychometric tests and that spatial test scores fit this general pattern. Normative scores are not available for spatial scores below the age of 13+, but small scale studies suggest that sex differences do not exist below this age (Wolf, 1971; Karnovsky, 1974 and this present study). It is thus possible that normative studies too might show sex differences on spatial tests as only commencing at 13[1], were they available for for years 10, 11 and 12. If this were shown, and it is speculative, then sex differences on spatial tasks would be shown to be similar to sex differences on VR+NA, only occurring a year or so earlier.

1. Nash showed no sex differences at DAT space relations, among 105 11 year old subjects, in an unpublished Ph. D. thesis abstracted by Maccoby and Jacklin, 1974 (abstracted page 549).

This speculation has important implication for the aetiology of sex differences on spatial tasks because it would suggest that such differences need not be ascribed a preponderately biological basis unless sex differences on psychometric tests such as verbal reasoning and numerical ability are seen as preponderately biological in origin as well. I shall return to this discussion in Chapter 9 where I shall show that sex differences on other measures also tend to increase with age (e.g., IQ, Bradway and Thompson, 1962 and school achievement, Forbes, 1975).

(ii) The second point emerging from the developmental data concerns the inconsistent increase of girls' scores on spatial tasks with year group. Yen's much larger study (n = 2508) showed similar effects. She concluded that on her spatial tasks mean scores increase consistently with grade only for boys (Yen, 1975B, p 288).

In my sample the inconsistency could perhaps be explained in terms of sampling. Perhaps the year groups of girls were not similar in intelligence. Table 30, showing scores on AH4, would not appear to bear this hypothesis out; with the exception of year one, where both boys and girls tended to score better than the subjects of the next two years[1], there was a fairly consistent trend of improvement with year. In any event such an explanation could not be offered for Yen's results in view of her large and representative samples (Yen, 1975B, p. 285).

How then is it possible to account for the inconsistency? It is conceivable that adolescent girls reach a threshold at spatial tasks beyond which they cannot improve. The control group scores, discussed in the last chapter, would appear to offer little support for this hypothesis. I suspect that the inconsistency is due to motivational factors. Girls may find spatial tasks conflict with their stereotype of what girls are good at. They look very mathematical in content and surveys tend to show that by secondary school, girls are falling behind in this, (see Forbes, 1975 and Table 45 presented in the previous section). Further girls may find the tests intrinsically less motivating than boys do.

Figure 8 shows graphically the answers to the question 'How much have you enjoyed this spatial test?' (referring to the Moray House Space

1. It will be remembered that this year group sampled mainly from one, and the most academic, feeder primary.

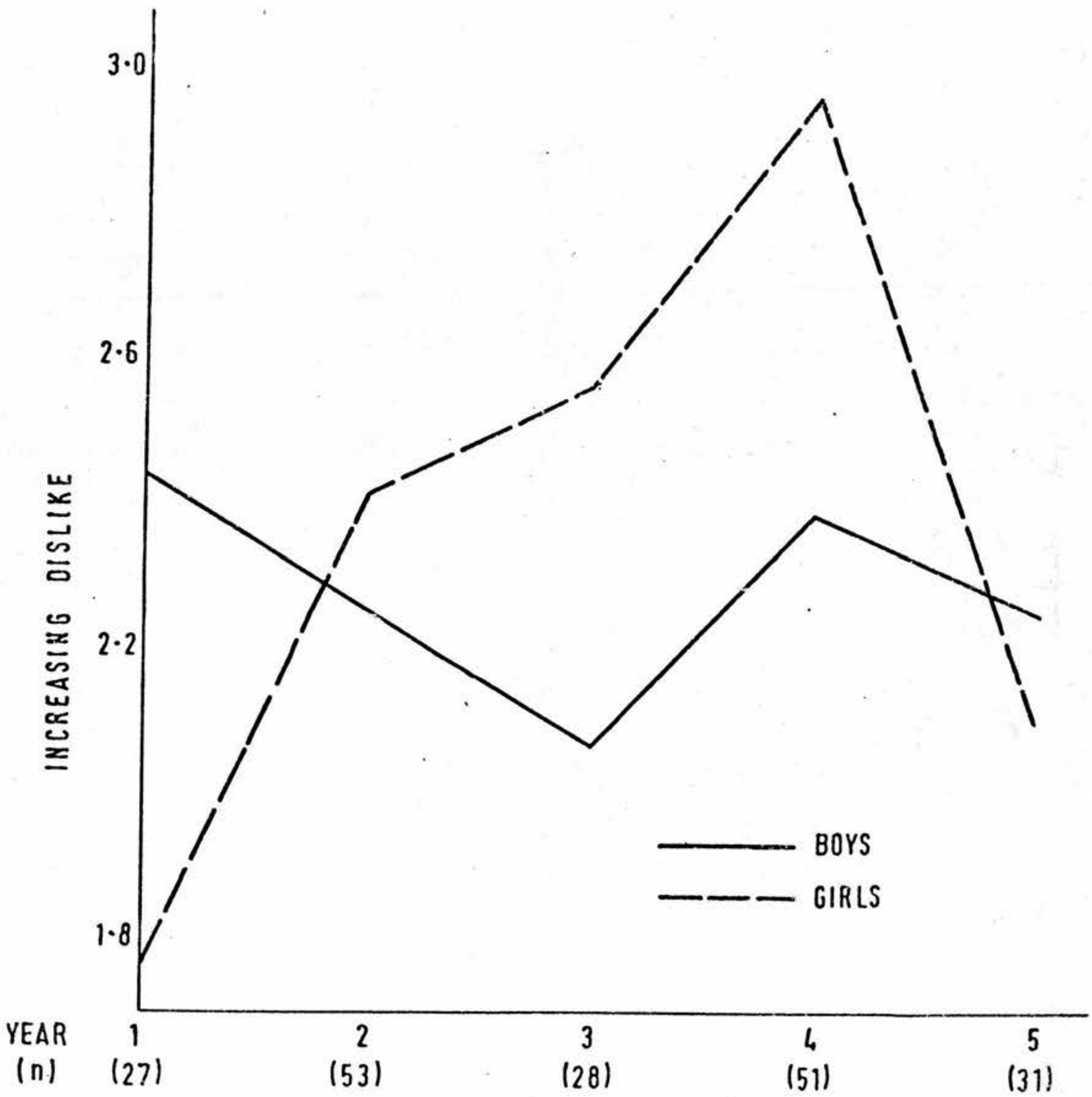

FIGURE 8: PROJECT TWO: DEVELOPMENTAL TRENDS OF MOTIVATIONAL LEVEL AT MS TEST, BY SEX (Boys, n = 88, Girls, n = 102)

test, see Appendix VI). It will be seen that in years 3 and 4 where the comparative decline on the spatial tasks sets in, girls' motivational level is lower than boys and further that their declared lack of enjoyment rises linearly with year from year 1 to 4[1]. This data does offer a little support, then, for the motivational hypothesis. I will return to this discussion in Chapter 9.

Before concluding this chapter on developmental trends, I would like to refer back to the comparatively low intercorrelations observed for the fifth year in project two (pp 165 - 168). When these were mentioned, I showed that it was not likely to be due to a lower motivational level for this year group. Another possible reason could be that sex differences in <u>patterns</u> of correlations were dissimilar, thus the total years' sample failed to show any overall significant correlations. To a certain extent this did hold in that boys' scores at MS1 and MS2 correlated reasonably well with AH4 but their scores at MS3 and MS5 did not, and for the girls the reverse held. However another possible reason for the lack of correlation in this age group

1. I have already suggested that the fifth year sample represented a more motivated set of girls than boys.

may lie in Butcher's observation that 'with increasing age, the relative importance of *g* becomes less, owing to the progressive differentiation of more specialised kinds of ability' (1970, p. 50).

I suggested in the last study that evidence for a clear and unambiguous spatial factor was not very strong. It may be then, that the different subtests measure abilities that become more differentiated with age, depending perhaps on relative experience with topics like solid geometry at the one academic extreme and woodwork at the other. Karnovsky (1974) showed that in her oldest age group, grade 7, although boys scored significantly better than girls at her spatial tasks, this did not hold for the pupils in high maths groups. This could be interpreted in two ways which are of course not mutually exclusive. Her tests, which were rotational ones, might have been highly loaded with *g* and the brighter pupils were probably in the highest maths groups, or relevant experience in mathematics might have improved performance on the space tests she used. I shall return to this in the next chapter.

CHAPTER SEVEN: VARIABLES MODIFYING PERFORMANCE ON SPATIAL TASKS

Introductory Note

Certain findings in the last two chapters have been interpreted as suggesting that sex differences in performances at spatial tasks are a product, to some extent at least, of social influences. I refer, for example, to the discussion in Chapter 5 where it was shown that girls tended to profit rather more from experience than boys did and that girls' scores on spatial tasks showed an inconsistent increase with age. Also in Chapter 6, I noted that developmental patterns in sex differences at spatial tasks were similar to developmental patterns in sex differences on other tasks such as numeric ability and verbal reasoning. In general these latter differences are not seen as biologically engendered (Maccoby and Jacklin, 1974) and I have suggested that sex differences at spatial tasks may share, at the least, similar origins with sex differences in the areas of other psychometric tests and academic achievements.

If sex differences on spatial tasks are seen as socially engendered, even if only in part, one would expect performance on the tasks to be modified by motivational and experiential variables and it is with these that this chapter deals.

Before proceeding further I would like to introduce a cautionary note. I have already observed that testing adolescents in a school situation does not necessarily engender highly motivated performance. The following incident that occurred in the administration of project two reinforces this contention. Part of the first booklet used in this project was a questionnaire concerned with the subjects' interests (see Appendix IV). In checking the booklets before they were marked by computor, I noticed that two subjects, both in the fourth year, had failed to complete this questionnaire. Rather than return the actual booklet, I contacted the pupils concerned, one a boy and one a girl and asked them to fill out a duplicate page each. In doing so they answered some questions they had previously answered in the booklet. I found the match for these answers was by no means perfect. The boys answered three out of five questions differently and the girl two out of four. It could be argued, of course, that out of 190 subjects these were the only two who had failed to follow instructions perfectly and that therefore it might be expected that their answers would not be totally reliable. Neverthless I think the incident does point to the fallibility of questionnaire data not only on the grounds of validity, a criticism which is often made (see for example Armistead, 1974), but also on grounds of reliability.

I shall report the results for each project separately and then discuss the results in a joint section, following the procedure I used in the previous chapters.

Reporting Results - 6. The Effect of Selected Variables in Project One

One of the variables incorporated in the analysis of variable design of project one (see Chapter 3, page 92) was the effect of sex of experimenter. In addition, in this project I was interested in laterality of the subject (as measured by the hand he/she wrote with), and the ability to identify the right hand correctly. Both of these areas had been suggested by my reading of the literature. For example, a number of studies had shown that sex of experimenter differentially affected boys and girls (see, e.g. Bittner and Shindeling, 1968) while other studies such as Levy (1969) had suggested that left-handed subjects were at a disadvantage on spatial and quasi-spatial tests. Other variables I investigated were ability at arithmetic and physical education as rated by the teacher, children's interests as indicated by the teacher and children's career choice. Finally I investigated the effect on the primary three and four groups of supplying the children with a verbal label for the Keogh shapes. I shall deal with each of these variables in turn.

(A) Sex of Experimenter Effects

In project one, equal numbers of both sexes were tested in each grade by male and female experimenters, (see Chapter 3). This enabled me to use analyses of variance as my basic statistical technique. In each of the analyses of variance there were two main variables - sex of experimenter and sex of subject giving one interaction term (sex of experimenter X sex of subject). In addition, as I noted in the previous three chapters both age and g (as measured by SIML and PICT) were covaried out. The 30 analysis of variance tables[1] can be found in Appendix VII, pp 476 - 506.

Main effects for sex of experimenter were significant on five analyses. In four of these subjects tested by the female experimenter, there were higher scores. The tables were those for EFT, both total and

1. Thirty tables because there were five quasi-spatial tests (MAZE, EFT, MAP 1, COMPLACE 1, COMPDIRE) x 6 samples (Total and grades 3-7).

primary five and MAP 1, both total and primary seven. There are two possible reasons for this. Firstly the female experimenter may have been less rigorous in applying the instructions or secondly as she tested the children before the male experimenter did, she may have been sent the brighter subjects first. Some support for the second of these hypotheses is afforded by the remarks made to her as she went to fetch the subjects. Three teachers indicated that to let her get into the swing of things, she had been given the brighter children first.

In any event as the sexes were balanced between the experimenters, if she did apply the instructions rather less rigorously, the effect would hold equally for both sexes. The male experimenter gave significantly higher scores for MAZE in primary six.

I was more interested of course in the interaction effects. It had been suggested (Siann, 1970) that girls might respond more confidently to a spatial or quasi-spatial task if they were tested by a female rather than a male experimenter. Of the 30 analyses that allowed this hypothesis to be tested, interaction effects were only significant on five. Of these five significant effects only two were in line with the hypothesis (Table 46). These results hardly provide powerful support for the hypothesis and may indeed be regarded as barely better than chance (two out of 30).

(B) Laterality of Subjects

In project one, experimenters labelled children as right or left handers, on the basis of the hand they wrote with. I am aware that this is a very crude indication of handedness (Annett, 1976), nevertheless I was interested to see how left-handed children performed on the five quasi-spatial tests. Table 47 shows that there were no marked differences between the groups and there would seem to be no evidence, from this study, that left handed children perform worse at spatial tasks.

(C) Ability to Identify Right Hand

I had been interested in whether being unable to identify the right hand would handicap performance at quasi-spatial tests. As might have been expected, it was only in primary 3 that this tended to occur with the sole exception of one girl in primary 7, who only identified her right hand correctly on one of the two occasions.

TABLE 46: PROJECT ONE: SIGNIFICANT INTERACTION EFFECTS FOR SEX OF EXPERIMENTER X SEX OF SUBJECT (n = 28 in each primary group)

TEST	GROUP	PROB. LEVEL INTERACTION	TEST IN LINE WITH HYPOTHESIS?		PROB. LEVEL TEST ON MEANS
EFT MAZE	P.5	.07	Yes.	Girls by female > Girls by male No difference for boys	.001
MAZE	P.6	.05	No.	Girls by male > Girls by female No difference for boys	.01
MAP 1	P.7	.008	Yes.	Girls by female > Girls by male No difference for boys	.01
COMP.	P.7	.018	No.	Boys by female > Boys by male No difference for girls	.06
COMPDIRE	TOTAL (n = 140)	.06	No.	Boys by female > Boys by male No difference for girls	.06

COMP = COMPLACE 1

TABLE 47: COMPARISON OF MEANS FOR RIGHT AND LEFT HANDERS IN PROJECT ONE

	PRIMARY THREE		PRIMARY FOUR		PRIMARY FIVE		PRIMARY SIX		PRIMARY SEVEN	
	R.(n=24)	L.(n=4)	R.(n=27)	L.(n=1)	R.(n=26)	L.(n=2)	R.(n=23)	L.(n=5)	R.(n=25)	L.(n=3)
EFT	6.12	8.25	7.22	8.00	9.69	7.50	9.30	8.00	10.88	11.67
MAZE	10.06	10.75	11.30	11.50	13.04	12.25	12.11	11.60	12.32	13.00
COMPLACE 1	114.60	150.00	135.80	173.20	148.10	154.90	150.40	163.90	149.20	149.90
COMPDIRE	96.20	78.30	96.60	177.00	108.10	93.90	110.00	108.90	114.00	149.40
MAP 1	6.75	6.75	7.67	10.00	9.15	7.50	9.30	9.80	9.16	11.67

KEY R. righthanded subject L. lefthanded subject

In primary 3, three boys and two girls were unable to identify their right hands correctly. Table 48 shows that while the five children in primary 3 did not perform markedly worse than their peers (with the exception of their performance at COMPLACE 1 which was significantly worse, $t = 2.39$, $p \leqq .02$), the girl in primary 7 who was unable to identify her right hand, was considerably worse at both EFT and MAP 1. It might be surmised that being unable to identify the right hand correctly had some bearing on her low score at MAP 1 and EFT.

(D) Ability at Arithmetic

Karnovsky (1974) found that ability at arithmetic affected sex differences in scores on spatial tests. In project one, I therefore asked teachers to rate their pupils' arithmetic ability using a four point scale.

These arithmetic ratings were then analysed against performance on the quasi-spatial tests by means of a one-way analysis of variance technique. For each test I used the rating as an independent variable and the test scores as a dependent variable. This was done for each test for each year for boys and girls treated together. Analyses

TABLE 48: PROJECT ONE: COMPARISON OF SCORES OF CHILDREN WHO WERE UNABLE TO IDENTIFY THEIR RIGHT HANDS

	PRIMARY THREE		PRIMARY SEVEN	
	Able to identify RH	Unable	Able to identify RH	Unable
	(n = 23)	(n = 5)	(n = 27)	(n = 1)
	Means	Means	Means	Means
EFT	6.52	6.00	11.11	7.00
MAZE	10.07	10.60	12.41	12.00
COMPLACE 1	126.60	87.40	150.40	122.80
COMPDIRE	94.80	88.20	117.50	149.40
MAP 1	6.78	6.60	9.60	6.00

by year showed no clear relationship[1], but as Table 49 shows, for the total sample, those children who were rated as better at arithmetic tended to do better at the tests, particularly if the two top groups are compared with the two bottom groups. The analysis of variance was significant only for EFT and it may be concluded therefore that there is a relationship between arithmetic ability and performance at this test.

(E) Ability at Physical Education

Vernon (1972) showed that scores on RFT were related to interest in outdoor and sporting activities for girls but not for boys. I was interested to see whether this relationship would be obtained with my sample as well. Consequently I asked the teachers to rate their pupils along a three point scale on interest and on ability at physical education. I performed one way analyses of variance, using the rating as the independent variable and the five quasi-spatial tests as the dependent variable. For the two sexes together no relationship obtained either for the total sample or for the

1. The sexes were grouped together as no consistent sex differences had been shown on raw scores for the quasi-spatial tests in project one (see Chapter 5).

TABLE 49: PROJECT ONE: ABILITY AT ARITHMETIC AND PERFORMANCE ON QUASI-SPATIAL TESTS

RATINGS:	1 (n = 54)		2 (n = 42)		3 (n = 22)		4 (n = 22)		F value
TESTS	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.	
EFT	9.44	3.54	9.43	2.54	6.86	2.49	7.00	3.46	6.55 *
MAZE	11.84	2.02	12.15	2.15	11.07	2.42	11.57	1.92	1.36
COMPLACE 1	144.70	30.40	152.10	22.80	127.70	33.60	127.10	33.20	5.47
COMPDIRE	114.80	46.50	104.00	43.60	105.90	30.70	84.20	35.90	2.80
MAP 1	8.63	2.44	8.79	2.71	8.14	1.75	7.82	1.99	1.06

Key * $p \leq .05$

years considered separately. Similarly when the analyses of variance were repeated for the sexes separately, no relationship was shown between the rating at physical education and any of the five quasi-spatial tests, so that there was no support for Vernon's 1972 findings. I shall discuss possible reasons for this non-replication at the end of this chapter.

(F) Interests

In the next chapter I will be discussing the effect of gender stereotypes on sex differences in spatial ability. It seems that certain areas of cognitive ability are seen as more appropriate to one or other of the sexes by the general public (see for example 'Reversing the Pecking Order', Clwyd, 1977). Consequently I asked the teachers whether they felt that any of their pupils showed interests and abilities that were more appropriate to the other sex. None of the teachers felt that any of their pupils fell into this category and they all accepted the question as a perfectly legitimate one, none querying what I meant. Indeed they tended to reply that all the children were 'proper little boys or girls' and there were no tomboys on the one hand or effeminate little boys on the other among them. These answers by the teachers reinforce, I think, the strength of stereotyped views about there being areas that are appropriate to one or other sex.

Some studies (e.g. Vernon, 1972 and Mayo and Bell, 1972) have suggested that spatial ability tends to be associated with artistic interests and ability. I asked the teachers whether they thought any of the children in their classes showed any evidence of artistic interest and ability or ability at and interest in model building or draughtmanship. Table 50 compares the mean scores on the quasi-spatial tests of the children who were seen as falling into this category and their classmates.

Inspection of Table 50 does suggest that the 'artistic' children were slightly superior at EFT (directionally in four grades, and significantly in one). This accords well with the finding of Mayo and Bell (1972) who found that high scores on EFT were associated with ability at art for college students.

(G) Career Choice

The experimenters asked each subject what they planned to do when they left school and why they wanted to make the particular choice they indicated. I am aware that this is a rather unrealistic question

TABLE 50: PROJECT ONE: COMPARISON OF MEANS FOR 'ARTISTIC' CHILDREN AND OTHER CHILDREN

	PRIMARY THREE		PRIMARY FOUR		PRIMARY FIVE		PRIMARY SIX		PRIMARY SEVEN	
	Art.	Other	Art.	Other	Art.	Other	Art.	Other	Art.	Other
	(n=6)	(n=22)	(n=2)	(n=26)	(n=5)	(n=23)	(n=5)	(n=23)	(n=6)	(n=22)
EFT	9.50	5.59***[1]	6.00	7.34	12.00	9.00	10.80	8.69	11.33	10.86
MAZE	10.92	9.95	10.75	11.35	14.20	12.70*[3]	13.00	11.80	12.50	12.36
COMPLACE 1	133.30	115.90	103.30	139.60*[2]	147.10	148.90	159.00	151.40	154.70	147.90
COMPDIRE	86.13	95.70	88.70	99.30	138.00	100.30	98.00	112.40	98.60	123.00
MAP 1	5.83	7.00	6.50	7.85	10.00	8.83	10.80	9.09	10.67	9.09

KEY Art. artistic *** $p \leq .001$ * $p \leq .05$

1. $t = 4.04$ 2. $t = 2.05$ 3. $t = 2.18$

for children in the primary age group, but I wanted to see if there were any pupils, particularly girls, who declared an interest in architecture or draughtsmanship or art and investigate whether this intention was associated with higher than expected scores on the quasi-spatial tests. In the event the solitary answer in this area was a little boy in primary 3 who said he wanted to be an artist because 'I like drawing and painting'. Not surprisingly he was one of those who was classed by the teacher as 'artistic' and his EFT score of 11 was well above the class mean of 6.43.

(H) Meaningful Keogh Shapes-stimulus properties of Keogh shapes

In Chapter 3 (page 97) I described how the abstract shapes Keogh used were matched to shapes to which a verbal label could be attached. For example, as Appendix 8 will indicate, the rectangle became a candle. I wished to investigate whether there would be an interaction between type of shape (whether meaningful or abstract) and sex of subject. Results indicated no interaction. For the two grades (Primary 3 and 4) that did the drawings, no difference on the types of shapes were obtained for either sex. In the case of the walking exercise, both sexes in primary 4 performed worse at the meaningful compared to the abstract shapes (4.3 points on average worse in the case of the girls, and 2.9 points on average in the case of the boys).

Reporting Results - 6. The Effect of Selected Variables in Project Two

As I mentioned in Chapter 3, I did not investigate sex of experimenter effects in the second project for two reasons. In the first instance I thought that at the secondary school stage girls would be well accustomed to male teachers and secondly the first project had not yielded any signficant effects for this variable.

In project two the modifying factors I investigated were children's interests, their career choices and their experience of woodwork and technical drawing.

The section referring to their interests can be seen in Booklet 2, page 12, Appendix IV. It will be noted that it comprises forced choice responses and relates only to selected activities that I had thought might have some bearing on performance at spatial tasks. The section referring to career choice comprised two questions, the first relating to what the subject planned to do on leaving school and the second to what they thought they would be doing at thirty years of age. This latter question was analysed only for the girls as I wanted to see whether interest in a career as opposed to being a housewife and mother related to performance at spatial tasks.

(A) Interests

In processing the questions about interest I produced contingency tables by running the ratings given on each interest scale against the scores on each spatial and quasi-spatial test. Each variable was dichotomised as near as possible to the median in order to avoid empty cells. Probability levels for the degree of association between the variables were then calculated by using either Chi squared[1] or Fisher's exact probability tests.

In this section I report, by interest[2], significant associations with the tests, where these were in the appropriate direction i.e. the greater the interest the higher the score. As might be expected some

1. Using Yate's correction where appropriate (see Nie et al, 1975)
2. The responses were analysed by year rather than by total. This was because different response patterns were shown for each year and this, combined with the general tendency for scores to increase with age, would have obscured any relationship between the ratings and the test scores for the total sample.

significant associations were shown in the other direction (four in fact). These appeared in no consistent manner and were regarded as being chance results that might be expected to appear when a large number of tables is being considered[1].

As the measurements of interest used were not very sophisticated, I have included in the tables relating to them, probability levels of ,10 and below instead of the more conventional level of .05 that I have used up to now.

The tables relating to the interests (50A to 50D) have been drawn up so that the reader can see whether the relationship holds only for one sex or for both and for the sample as a whole.

The interest that showed the most striking relationship with the scores on the tests of project two was chess. Table 50A shows that the association was most frequent for the second and fourth years and was more commonly shown for male than female groups. It is an open question

1. There were 400 tables (5 years X 8 tests X 10 interest questions).

whether there is any casual relationship between chess playing and performance at spatial tests. While I think it is possible that playing chess contributes to the ability to visualize at least in two dimensions, it is very likely that the more able children play chess and the more able children score above the median at the spatial and quasi-spatial tests.

The interest showing the second most frequent significant association with spatial scores was drawing and painting outside school hours. This is not an unexpected finding in view of the established relationship already referred to with at least one quasi-spatial test, (see Mayo and Bell, 1972 who showed this for EFT). Table 50B shows that once again this holds most frequently for the two largest samples but that unlike the relationship for chess it holds equally for boys and girls.

Both doing woodwork/making models outside school hours and playing with Lego/Meccano when younger, showed associations with test scores. Table 50C combines the results on these two interest questions. It can be seen that the association holds equally often for the sexes considered separately but that the majority of the associations were with the sexes considered together.

I had thought that an association might be shown between orienteering and cycling and the directional test, COMPLACE 2. This hypothesis was not supported at all for orienteering though cycling did show a slight relationship with COMPLACE 2 for the first year boys at the .10 level and for the second year total group at the .04 level. In addition cycling showed a relationship with MAP 2 for years one and five total samples at the .10 and .05 levels respectively. These associations, though not striking, do point to the role of experience in some quasi-spatial tests.

Four of the questions were answered in the affirmative by girls only, these were the two questions related to knitting and crocheting and the two related to making clothes. Neither of the questions concerned with knitting and crocheting showed any relation to test scores, but as Table 50D shows there was a clear association between making clothes/drafting patterns and spatial scores above the median. It is, I think, particularly noteworthy that 3 of the 5 years showed a significent relationship between these activities and the total MS score.

TABLE 50A: SIGNIFICANT RELATIONSHIPS BETWEEN CHESS PLAYING AND SCORES ABOVE THE MEDIAN ON SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO (Chi squared and Fisher's exact test)

YEAR	TEST	TOTAL SAMPLE		BOYS		GIRLS	
		n	prob. lev.	n	prob. lev.	n	prob. lev.
1	MAP 2	27	n.s.	14	.09*	13	n.s.
2	MS3	53	.07*	24	n.s.	29	n.s.
	MS4	53	.09*	24	.03**	29	n.s.
	TOTMS	53	.07*	24	n.s.	29	n.s.
	COMPLACE 2	53	.02**	24	n.s.	29	.005***
4	MS1	51	.03**	24	.004***	27	n.s.
	MS2	51	.004***	24	.06*	27	n.s.
	MS5	51	.005***	24	.01***	27	n.s.
	TOTMS	51	n.s.	24	.02**	27	n.s.
	MAP 2	51	n.s.	24	.05**	27	n.s.
5	MS3	31	.05**	12	n.s.	19	n.s.
	COMPLACE 2	31	n.s.	12	n.s.	19	.08*

KEY *** $p \leq .01$ ** $p \leq .05$ * $p \leq .10$

TABLE 50B: SIGNIFICANT RELATIONSHIPS BETWEEN DRAWING AND PAINTING AND SCORES ABOVE THE MEDIAN AT SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO (Chi squared and Fisher's exact test)

YEAR	TEST	TOTAL SAMPLE		BOYS		GIRLS	
		n	prob.lev.	n	prob.lev.	n	prob.lev.
1	MS2	27	.08*	14	n.s.	13	n.s.
2	MS1	53	.08*	24	.08*	29	n.s.
	MS2	53	.01***	24	.04**	29	n.s.
	MS3	53	.08*	24	.08*	29	n.s.
	MS4	53	.008***	24	.02**	29	n.s.
	MS5	53	.003***	24	.05**	29	.08*
	TOTMS	53	.003***	24	.06*	29	.06*
	COMPLACE 2	53	n.s.	24	n.s.	29	.04**
4	MS3	51	n.s.	24	n.s.	27	.06*
	MS4	51	.09*	24	n.s.	27	.06*

KEY *** p≦.01 ** p≦.05 * p≦.10

TABLE 50C: SIGNIFICANT RELATIONSHIPS BETWEEN DOING WOODWORK OUTSIDE SCHOOL HOURS/ MAKING MODELS/ PLAYING WITH MECCANO AND LE GO/ AND SCORES ABOVE THE MEDIAN AT SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO (Chi squared and Fisher's exact test)

YEAR	TEST	TOTAL SAMPLE		BOYS		GIRLS	
		n	prob.lev.	n	prob.lev.	n	prob.lev.
1	MS3	27	.03**	14	.05**	13	n.s.
2	TOTMS	53	.05**	24	n.s.	29	n.s.
	MAP 2	53	n.s.	24	.10*	29	n.s.
	COMPLACE 2	53	.06*	24	.04**	29	n.s.
3	MS4	28	.10*	14	n.s.	14	n.s.
4	MS1	51	.07*	24	n.s.	27	.10*
	MS2	51	.007***	24	n.s.	27	.02**
	MS5	51	.006***	24	n.s.	27	.02**
	TOTMS	51	.03**	24	n.s.	27	n.s.
5	MS3	31	.03**	12	n.s.	19	n.s.
	MAP 2	31	.10*	12	n.s.	19	n.s.

KEY *** $p \leq .01$ ** $p \leq .05$ * $p \leq .10$

TABLE 50D: SIGNIFICANT RELATIONSHIPS BETWEEN MAKING CLOTHES/ MAKING PATTERNS FOR CLOTHES OUTSIDE SCHOOL HOURS/ AND SCORES ABOVE THE MEDIAN AT SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO (Chi squared and Fisher's exact test) GIRLS ONLY

YEAR	TEST	n	prob.lev.
2	MS2	29	.05**
	MS5	29	.08*
	TOTMS	29	.03**
	COMPLACE 2	29	.10*
3	MS2	14	.03**
	TOTMS	14	.001***
	MAP2	14	.02**
	COMPLACE 2	14	.05**
4	MS4	27	.06*
5	TOTMS	19	.07*
	COMPLACE 2	19	.09*

KEY *** $p \leq .01$ ** $p \leq .05$ * $p \leq .10$

(B) Woodwork and Technical Drawing Classes

The subjects in project two were all asked if they had attended woodwork and technical drawing classes. All the boys in years 2 to 5 had done so and none of the girls in these years had. Thus there was no relevant data to analyse for these years. Approximately half the subjects of both sexes in the first year had[1], but no relationship was shown for this year group between attending such classes and test scores. As the first years had only attended such classes for one term, these results are not surprising.

(C) Career Choice

Before discussing the effect of vocational choice on test scores, I would like to present the results pertaining to the question about what subjects thought they would be doing at the age of thirty[2].

1. It is of interest to note that it is just in this academic year (1976-1977) that such classes were on offer to girls as well as boys.
2. The question read 'What do you think you will be doing when you are thirty years old?' If the subjects asked for clarification I replied 'Can you think of someone of that age? What do they do? Will you be doing the same sort of thing?' Most subjects responded as I expected with references to work and marriage (both boys and girls tended to refer to the latter). However one fourth year responded that he would be 'drinking'.

I had hypothesised that those girls who showed a commitment to careers would obtain higher scores at the tests. Table 51 shows this hypothesis to receive weak confirmation. On the whole, those who had indicated that they would be working either full or part time tended to score higher than those who said they would be housewives/mothers or that they didn't know. However, not much reliance can be placed on this result as the difference was only significant in one case.

In analysing the responses to the question about career choice, I dichotomised into areas that I considered demanded some awareness of spatial relationships and areas that I considered made no such specific demands. Into the former category I grouped the following - art, architechture, draughtsmanship (including civil engineering) and design.

I compared the scores on the spatial and quasi-spatial tests, of subjects who indicated that they wanted to pursue careers in art, architecture, draughtsmanship or design with the scores of their peers. On the whole, boys who indicated such choices tended to score higher than the rest of their year.

TABLE 51: COMPARISON OF MEAN SCORES OF GROUP A GIRLS WITH GROUP B GIRLS, PROJECT TWO.

YEARS	1	2	3	4	5
TEST	(A, n= 3) (B, n=10)	(A, n=13) (B, n=16)	(A, n= 2) (B, n=12)	(A, n=20) (B, n= 7)	(A, n=10) (B, n= 9)
MS1	A higher	B higher	A higher	A higher	A higher
MS2	A higher	B higher	A higher	A higher	B higher
MS3	A higher	A higher	A higher	A higher*	A higher
MS4	B higher	A higher	A higher	A higher	A higher
MS5	A higher	B higher	A higher	A higher	A higher
TOTMS	A higher	B higher	A higher	A higher	A higher
COMPLACE 2	A higher	A higher	A higher	A higher	A higher
MAP 2	B higher	B higher	B higher	A higher	B higher
Number of times A higher (out of 8)	6	3	7	8	6

KEY
*$t=2.47$ $p \leq .02$ GROUP A GIRLS PLAN TO BE WORKING AT THIRTY YEARS OF AGE, GROUP B GIRLS DO NOT.

However this was a marginal trend (26 out of 40 comparisons) and only reached significance in one comparison. Contrasting the scores of the girls making these choices with their peers showed much more striking differences. They performed better in 28 out of 32[1] comparisons, significantly so in five cases.

I had hypothesised that girls making these choices would not score significantly differently from boys making these choices on the spatial and quasi-spatial tests. Tables 52A and 52D confirm this hypothesis for each year separately. With the exception of COMPLACE 2[2] even the last two years show no significant sex differences. In addition, as Table 52E shows, the Moray House Space test total score and the MAP 2 score for these girls tended to be higher than the scores of their year peers whether male or female.

Thus it would appear that girls electing careers in the areas I had selected as requiring good spatial skills did, in fact, perform significantly better than their peers at spatial tasks.

1. There were only 32 comparisons for the girls because no girls in year three indicated any of these career choices.
2. It will be remembered that this test did not correlate at all with the other tests used in project two.

TABLE 52A: SEX DIFFERENCES ON THE SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO, FOR THOSE WHO PLAN CAREERS IN ART/ARCHITECTURE/DRAUGHTSMANSHIP/DESIGN, YEAR ONE (boys, n=3; girls, n=2)

	MS1	MS2	MS3	MS4	MS5	TOTMS	MAP 2	COMPLACE 2
Boys								
Mean	2.33	11.67	3.33	5.67	2.67	25.67	10.67	6.33
s.d.	1.53	4.51	1.53	1.53	3.05	8.63	1.53	3.51
Girls								
Mean	1.50	21.00	4.50	5.00	4.00	36.00	9.00	11.00
s.d.	2.12	2.83	2.12	2.83	0.00	5.66	2.83	0.00
t	0.52	-2.54	-0.73	0.36	-0.59	-1.46	0.89	-1.78
prob.lev.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY positive values of t indicate difference in favour of boys, negative in favour of girls.

TABLE 52B: SEX DIFFERENCES ON SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO FOR THOSE WHO PLAN CAREERS IN ART/ARCHITECTURE/DRAUGHTSMANSHIP/DESIGN, YEAR TWO (boys, n=4; girls, n=3)

		MS1	MS2	MS3	MS4	MS5	TOTMS	MAP 2	COMPLACE 2
Boys									
	Mean	9.00	19.00	4.25	5.25	3.00	40.50	9.50	9.50
	s.d.	4.08	5.23	2.50	1.71	4.00	15.80	4.36	0.58
Girls									
	Mean	7.67	18.00	4.33	4.00	2.33	36.33	9.67	8.33
	s.d.	3.21	7.21	2.08	2.00	0.58	14.15	2.52	1.53
	t	0.46	0.21	-0.05	0.89	0.28	0.36	-0.06	1.43
	Prob.lev.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY Positive values of t indicate difference in favour of boys, negative of girls

TABLE 52C: SEX DIFFERENCES ON SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO FOR THOSE WHO PLAN CAREERS IN ART/ARCHITECTURE/DRAUGHTSMANSHIP AND DESIGN, YEAR FOUR (boys, n=5; girls, n=2)

	MS1	MS2	MS3	MS4	MS5	TOTMS	MAP 2	COMPLACE 2
Boys								
Mean	11.22	22.00	5.60	6.00	5.40	50.20	12.80	10.00
s.d.	0.84	1.87	2.07	1.23	1.67	3.56	0.45	1.00
Girls								
Mean	10.50	23.00	5.50	6.50	6.50	52.00	12.50	7.00
s.d.	2.12	1.41	0.71	0.71	2.12	5.66	0.71	1.41
t	0.69	-0.67	0.06	-0.52	-0.74	-0.53	0.70	3.27
Prob.lev.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	.02*

KEY: Positive values of t indicate difference in favour of boys, negative of girls.
$* = p \leq .05$

TABLE 52D: SEX DIFFERENCES ON SPATIAL AND QUASI-SPATIAL TESTS OF PROJECT TWO FOR THOSE WHO PLAN CAREERS IN ART/ARCHITECTURE/DRAUGHTSMANSHIP/DESIGN, YEAR FIVE (boys, n=2; girls, n=3)

	MS1	MS2	MS3	MS4	MS5	TOTMS	MAP 2	COMPLACE 2
Boys								
Mean	9.50	20.50	5.50	7.00	5.50	48.00	13.00	10.00
s.d.	3.54	2.12	0.71	0.00	3.54	5.66	0.00	0.00
Girls								
Mean	9.67	23.00	4.33	5.67	3.67	46.33	12.67	8.33
s.d.	2.52	1.73	1.15	1.16	3.05	1.15	0.58	0.58
t	-0.06	-1.46	1.24	1.55	0.62	0.54	0.77	3.87
prob.lev.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	.03*

KEY Positive values of t indicate difference in favour of boys, negative of girls.

*=$p \leq .05$

TABLE 52E: MEAN SCORES ON TOTMS AND MAP 2 FOR GIRLS WHO PLAN CAREERS IN ART/ARCHITECTURE/DRAUGHTSMANSHIP/DESIGN, 'ARTY GIRLS', COMPARED TO THEIR YEAR GROUPS, PROJECT TWO

	Year 1			Year 2			Year 4			Year 5		
	arty girls	other girls	boys	arty girls	other girls	boys	arty girls	other girls	boys	arty girls	other girls	boys
n	2	11	14	3	26	24	2	25	24	3	16	12
TOTMS	36.00	27.17	28.85	36.33	34.38	32.75	52.00	32.16	42.21	46.33	36.82	43.67
MAP 2	9.00	8.41	10.21	9.67	8.66	8.87	12.50	9.35	11.42	12.67	11.13	11.92

(D) Coaching

I have already discussed some of the results of the coaching exercise in Chapter 5, when I showed that girls tended to gain rather more from experience than boys did. In this chapter, I shall discuss the more general aspect of this data. Tables 53A and 53B compare the gains made on the second test session for the control and experimental groups for the two years considered. It will be seen that these were not markedly higher for the coaching group. In only one of the 12 comparisons did the difference reach significance and in three of the six comparisons for the fourth year the control groups gained more.

I do not think that these tables should be taken as showing that coaching cannot produce significant differences in scores over and above those due to experiencing the test a second time. I have already remarked that I thought the coaching session followed too closely on the test administration and that it was too short. Some support for this interpretation is that the greatest gains for both years for the coached group compared to the control group were on MS 1 which was both the first subtest covered by the tutor and the one that was covered in the greatest detail and for the longest time.

TABLE 53A: COMPARISON OF MEAN GAINS FOR COACHING, COMPARED TO THE CONTROL GROUP

YEAR TWO, PROJECT TWO

	MS1	MS2	MS3	MS4	MS5	TOTMS
Coaching n=27						
Mean	2.15	1.33	0.63	1.44	1.15	7.70
s.d.	3.28	3.92	1.54	1.98	2.11	7.32
Control group n=26						
Mean	0.85	1.62	0.38	1.35	0.85	5.04
s.d.	2.98	2.99	1.47	1.50	1.69	6.19
t	1.51	0.75	0.59	0.20	0.58	1.43
prob.lev.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

KEY positive t indicates difference in favour of coaching group

TABLE 53B: COMPARISON OF MEAN GAINS FOR COACHING COMPARED TO THE CONTROL GROUP

YEAR FOUR, PROJECT TWO

		MS1	MS2	MS3	MS4	MS5	TOTMS
Coaching n=28							
	Mean	2.36	2.04	0.89	0.75	2.64	8.68
	s.d.	2.75	2.65	1.50	1.69	2.63	6.02
Control group n=23							
	Mean	0.91	2.30	1.52	1.22	1.30	7.09
	s.d.	2.68	2.69	1.38	1.73	2.01	6.32
	t	1.89	-0.36	-1.55	-0.97	2.27	0.91
	prob.level	(.06)	n.s.	n.s.	n.s.	.03*	n.s.

KEY * $p \leq .05$ positive value of t indicates difference in favour of coaching group
negative value of t indicates difference in favour of control group

Discussion

My presentation of the results of the two projects has been facilitated by the extremely powerful computing tools now available to the researcher. Not only was I able to mark all the responses of the second project by computer[1], thus obviating any involuntary biases on my part, but by use of the extremely versatile SPSS[2] package I was able to produce all the statistical analyses with comparatively little effort.

The facility offered by computers has, however, insidious drawbacks - the practice of data dredging becomes very tempting. Particularly in the compilation of questionnaire results, in taking, as I did, the .10 probability level as significant, the dangers of type 1 errors are very real[3]. For this reason I have been extremely careful in the contingency table results I have presented (pp 301 - 304) not to report the odd significant relationship that was shown just once or twice between the independent variables and the test scores[4].

1. Using a special FORTRAN program which I wrote for the purpose.
2. Statistical Package for the Social Sciences (Nie et al, 1975)
3. That of rejecting the null hypothesis too readily, see Edwards 1958 pp133-34.
4. For example, a significant relationship was shown just once with the question about knitting and crocheting.

In discussing the results presented in this chapter, I would like to distinguish between three classes of variables that appeared to relate to performance at spatial tasks. These are:

(a) Abilities and interests

(b) Specific experiences

(c) Motivational variables

(a) Abilities and Interests

In Chapter 4 I showed that the quasi-spatial tests I used in project one were loaded with *g* and thus any measure of general ability should show an association with performance at these tests. Table 49 summarised the relationships the tests showed with the rating teachers made of the children's arithmetical ability. Although not marked, there seemed to be a consistent tendency for children classed in the two upper groups to outscore children in the lower groups.

Karnovsky (1974) showed that in the 7th grade, ability at mathematics bore on performance at spatial tests. It may have been that this relationship was due to underlying general ability or that facility at mathematics brings with it familiarity with stimuli of the type used in spatial tests, or that a general facility at spatial tasks contributed to good performance on both measures, or indeed any combination of the three suggested causes. Neither her data nor mine are sufficient to tease out these relationships. Certainly it suggests that further research in this area could be undertaken using not only, as I did in project two, different spatial tasks and a measure of g but also standardised measures of performance at different branches of mathematics.

That children who played chess in the second project also tended to outscore other children on the spatial tasts is not an unexpected finding (Table 50A). Once again, as I noted on p 299 the direction of the relationship is not clear. Perhaps a research project in this area could be mounted in which children who had never played chess did a general spatial test, such as the Moray House Space test, then played chess for a period and then redid the test, while a control group merely did the MS test twice.

Turning from general ability to rather more specialised abilities, I did not replicate Vernon's association of quasi-spatial tests with ability at athletic pursuits. (p 290). Vernon himself showed positive correlations for girls only and writes that 'It is difficult to suggest any explanation for this, but it certainly raises questions for further research' (1972, p 385). It is my own impression that this finding of Vernon's may have been a chance association for the particular sample of girls he used.

In project one, I asked teachers to indicate which of their pupils they considered to be artistic and Table 50 shows that these children tended to outscore their peers at EFT. This finding replicates Mayo and Bell's (1972) finding, also using EFT, with college students. Looking at examples of an embedded figure test (Appendix VIII, pp 565- 70) it seems clear that ability to analyse shapes into component parts is a major demand of the items and this is, of course, an essential ingredient of any graphic art. However, not only does artistic ability appear to be associated with performance at quasi-spatial tasks such as EFT, but even interests in this area appear to predispose to higher scores on spatial tasks. Thus, Vernon (1972) found that secondary school pupils who indicated artistic interests tended to do better on a battery of spatial tests than their peers did.

Project two showed a similar finding (Table 50B) - those children who said they drew and painted outside school hours tended to do relatively better than their peers at the spatial tasks.

The last ability I wish to consider is the ability to identify the right hand. It had been suggested to me by a colleague that[1] in his research on driving he had found that women tended to have more difficulty in identifying their hands. He speculated further that this might have been a partial cause of their lower performance at spatial tasks. The present study has shown that even with a primary school sample, this inability is confined mainly to the youngest children tested. There was no evidence that at this level it was found more in girls than in boys (p 288). Nevertheless, the one older pupil who could not identify their right hand correctly was a girl who scored rather badly at the tasks. It is, of course, possible that adults who score badly at spatial tasks do also have difficulty in identifying their right hand but there is not sufficient data from the present study to substantiate this hypothesis nor the allied one that this inability is more common in women.

1. See Parry (1968)

Finally, it should be noted that there was no evidence from project one to support the contention that being left handed is a disability in the performance of quasi-spatial tests as claimed by Levy (1969).

(b) Specific Experiences

In selecting the questionnaire items relating to experience that might have facilitated performance on the MS test, I relied on close inspection of this test. It seemed to me that experience at reading two-dimensional representations of three-dimensional forms such as encountered in technical drawing would facilitate performance at MS 3, 4 and 5. Secondly, it seemed that experience of handling three-dimensional forms might have facilitated performance at MS 3 to 5. Finally, it occurred to me that the use of dress patterns in making clothes might have contributed to good performance at the Moray House Space test and particularly at section MS 2.

Unfortunately (see p 305) no data was available to confirm or disconfirm the hypothesis about technical drawing but table 50C shows that there was a clear indication of a relationship between experience of three dimensional forms (woodwork/model-making/lego/meccanno) and performance on the spatial tests. This experience contributed both to performance at two and three-dimensional sections. Similarly, experience at making clothes did seem to predispose to higher spatial scores (Table 50D). It is particularly striking that a relationship with the total MS score was shown for years 2, 3 and 4. The conjectured specific relationship with MS 2 was shown for years 2 and 3.

With respect to the quasi-spatial tests used in project two, I had hypothesised that cycling and orienteering experience might have predisposed to higher scores at both map reading (MAP 2) and location of specific places (COMPLACE 2). Orienteering showed no such association but there was an indication that cycling experience did contribute to higher scores at both these tests (p 300). As I noted before, though not striking, these results do point to the role of relevant experience in some quasi-spatial tests and in particular lead one to question the assumptions of researchers such as Hutt (1975A and 1975B) and Buffery and Gray (1972) that such skills are predictated on innate abilities.

I must confess I am unable to understand the association COMPLACE 2 appears to show with dressmaking (Table 50D), unless one assumes that those girls who are allowed more freedom are also the girls whose circumstances force them to make rather than buy their own clothes, but of course this is very speculative and the relationship displayed may be chance. It is however shown for 3 out of 5 years.

In general, I think it can be said that my data does support the overall hypothesis that specific types of experience are associated with higher spatial scores.

I have been unable to find any other studies that directly relate specific classes of experience such as I have described to performance at spatial tests, but certain cross-cultural studies do show that appropriate experience can influence performance on quasi-spatial tasks. Nerlove _et al_ (1971) reported that Kenyan children with greater environmental experience were better than their peers at tasks such as copying geometric patterns and block patterns and doing mazes. Similarly in South Africa, Du Preez (1968) showed that performance at RFT correlated with distance travelled from home.

In concluding this subsection I would like to refer back to my coaching study. This has suggested that specific coaching did not boost scores much above simple repetition of the test (Tables 53A and 53B). I have discussed this on p 111 and p 118 and indicated that I think the motivational level was not sufficiently high at the coaching session to provide an adequate test of the efficacy of coaching.[1] The other finding associated with the coaching data was that experience of the test for the second time boosted the scores of the control girls more than the control boys and I will discuss this finding further in the next and last subsection of this chapter.

(c) Motivational Variables

In presenting the theory that sex differences on performance at spatial tests are largely due to social variables (chapter 2 pp 34- 36) I suggested that girls may approach spatial tests rather less confidently than boys do. The rationale for this is that the stimuli used in these tests are typically abstract and geometric shapes and are very similar to those found in mathematics. Girls on the whole are less confident in this area (Clwyd, 1977). Furthermore, boys usually have more experience of stimuli of these

1. Particularly as other studies have shown positive gains on spatial tests for coached samples (Sherman 1967 and see p 346).

types due to their exposure to technical drawing and once again this may give them a motivational edge. I had further suggested that with young girls, a male experimenter may be less reassuring than a female experimenter in the test situation.

Dealing with the first of these hypotheses first, Table 46 showed that no support at all was offered for it. There was no interaction at all between sex of experimenter and sex of subject. It may have been that the male experimenter who did most of the testing was so gentle and caring in his approach that he presented a very similar image to the female experimenter. In any event, project one failed to replicate sex of experimenter effects that have been shown by, for example, Bittner and Schindeling with a Piagetian task (1968).

That girls are less confident in the face of spatial tests is a harder hypothesis to test. In this study I attempted to do so in three ways:

(i) Directly by manipulation of test items. Thus in the administration of the Keogh pattern copying test, as well as using her geometric shapes, I also used meaningful shapes.

(ii) If it is assumed that girls with more stereotyped role expectations also have more stereotyped attitudes to test situations, the following prediction could be made: girls who saw themselves primarily as wives and mothers would score less at the relatively 'unfeminine' spatial tests.

(iii) If those girls who had set themselves career goals which involved some use of spatial relationships (ie, art/architecture/draughtsmanship/design) scored higher than other girls as well as higher then boys with the same aspirations, it could be argued that this was due to their atypically (for girls) high motivation on spatial tasks.

I will now discuss the results of these three tests of the hypothesis that links girls' lower spatial scores with motivational variables.

(i) I have already mentioned the study by Milton (1957) in which he manipulated the content of reasoning items and showed an interaction with sex of subject and item content. Similarly, Clwyd (1977) noted that the same effect has been shown with examination questions. 'There is some sex bias possible in exams. A mathematical problem for example which took its subject a woman buying quantities of lace and satin in a shop, or alternatively a stockbroker charging different rates of commission for buying and selling stocks. Although the problem to be solved was identical, the women found the stockbroker example much harder to solve' (p.9).

I have been unable to find any such manipulation of the content of spatial problems in the literature but I myself showed some interaction with stimulus content and sex of subject on an overlapping shapes task in my Zambian study (see p. 36 and Appendix VII pp 571 - 573). (Siann, 1970). In the present study I hypothesised that making the Keogh shapes more meaningful by asking the subjects to copy similar shapes which looked like everday objects and were so labelled (see Chapter 3, p 97 and Appendix VII pp 575 - 577), might interact with sex of subject. Page 295 shows that this hypothesis was not confirmed. In retrospect, I think it might have been better to test this hypothesis about stimulus content with the older age group where stereotypes were likely to have been more established.

(ii) The second test yielded results that tended to confirm indirectly the hypothesis linking spatial scores of girls with sex stereotypes. As Table 51 showed, those girls who did not regard themselves as primarily the wives and mothers of the future tended to score higher at the spatial tests. This finding can perhaps be related to that of Nash (1974) who showed that, whereas in general 14 year old boys scored significantly higher than 14 year old girls at the DAT space relation test, those girls who would have preferred to be boys did not score lower than boys.

(iii) The results presented in Tables 52A to 52E have showed that those girls indicating that they wished to pursue careers in areas where understanding of spatial relationships might be of a help (art/architecture/draughtsmanship/design) tended to score higher at spatial tests than their peers did. In addition, in the two oldest year groups, where general sex differences in favour of boys were large (Chapter 5), they scored equally well compared to boys electing the same careers and better than boys in the class as a whole. These findings would appear to suggest that where girls see test content as appropriate they score comparatively higher. It is not likely that their higher scores are only due to an interest in the area because the same effect was not shown for the boys. That is, boys electing careers in this area did not outscore their peers.

It would seem that (ii) and (iii) above do offer some indirect support for the hypothesis that girls in general tend to see spatial tests as inappropriate but that if they either regard themselves as career oriented and/or have career aspirations in relevant areas, then their performance at spatial tasks tends to be higher than that of their peers.

The support referred to above rests on very small numbers and should be regarded as very tenuous. Any further test of the hypothesis should use greater numbers and include more sophisticated motivational measures. In addition, intelligence should be held constant.

Finally, I would like to refer back to the sex difference shown by the control group (pp229 -236). I have already discussed the motivational implications of this and suggested that exposure to spatial items might serve to familiarise girls with test stimuli, thus accounting for the sex difference shown. That some sex differences may be a matter of familiarity is a conclusion reached by Maxwell et al, (1975) in a study of sex differences on Piagetian tasks. They showed that with instruction, sex differences on these tasks diminished and concluded that (p 131) 'Perhaps if the socialisation of girls were more similar to that of boys in opportunities for handling and viewing objects in games, the sex difference would diminish, since females were able to profit significantly from instruction.'

In conclusion, I think that this chapter has offered support for the general contention that performance at spatial tasks can be modified by social variables. It has been shown that general ability as well as specific abilities such as artistic ability may modify performance at these tasks. It has also been shown that both interests and specific experience may affect performance at spatial tasks. Finally, it has been shown that girls who are more career oriented, particularly in relevant areas, tend to do better at these tasks.

CHAPTER EIGHT: SUMMARY OF PROCEDURE AND RESULTS OF THE TWO PROJECTS

Introductory Note

In the last four chapters the detailed results of the two projects were reported and discussed. This was done by grouping the results under four headings - the nature of spatial ability (Chapter 4), sex differences in performance at spatial tasks (Chapter 5), developmental trends in sex differences on spatial tasks (Chapter 6), and the effect of selected variables on performance at spatial tasks (Chapter 7). Before attempting to synthesise and interpret these results, I would like briefly to summarise both the procedure and the major results of the two projects.

Procedure of Project One

This project was concerned with the primary school age group. 140 children (70 of each sex) were drawn from a state co-educational school in Edinburgh whose intake was largely middle class. Five age groups were represented, ranging from 7+ to 11+. 28 children were tested in each age group, equal numbers of each sex being drawn. The children were tested individually by either a female or male experimenter, balancing for sex of subject and experimenter within each age group.

In this project five quasi-spatial tests were used[1], on which sex differences in favour of males had been reported. These were an embedded figure test, a maze test, a map visualization test (the ability to say whether a given intersection on a specified path involved a left or a right hand turn), and two tests of directional ability (the ability to point out locations in the neighbourhood and the ability to point out compass directions). In addition, each subject did two subtests of the WISC (the similarities and the picture arrangement subtest) in order to obtain a measure of g. All the 5 teachers concerned were interviewed in order to get information about the subjects'ability at mathematics (arithmetic), physical education and art. All of these had been reported in the literature as bearing on spatial ability.

The primary 3 and 4 age groups performed one other task. They were asked to copy patterns by both drawing them (primary 3 and 4) and by walking them (primary 4 only) on a large blackboard, wearing wool socks which had been saturated with chalk. This test was included as it had been reported that boys were better than girls at the walking component of this task.

1. This term had been coined to refer to tests which were reported in the literature as being largely spatial in nature as no standard spatial tests were available for the primary school age group.

Procedure of Project Two

190 subjects (102 girls and 88 boys) were tested from the state co-educational secondary school for which the school used in project one was a feeder school. Once again five age groups were used, 12+ to 16+. The subjects were tested in a group situation and thus equal numbers of boys and girls were not obtained either for the individual age groups or for the total group. Each test session was conducted by two experimenters, one male and one female.

22 of the 27 first year tested had formed part of the oldest age group in project one and thus these 22 children formed a small longitudinal sample.

All the subjects completed the Moray House Space test, comprising 5 subtests. This lasted half an hour. In addition, two quasi-spatial tests analagous to those used in project one were done - a test of directional ability (ability to point out locations in the neighbourhood) and a test map visualization (analagous to the one done in project one). All subjects also completed part I of the Alice Heim test of general intelligence and answered questions about their interests and vocational aspirations.

A small coaching study was undertaken for the second and fourth year age groups. In each year one group of subjects repeated the Moray House Space test at a two week interval (the control groups) and a second group had 50 minutes coaching after the first administration of the Space test and then repeated the test after a two week interval (the experimental group). In all except the analyses relevant to the coaching study, the scores of the first test administration were used in order to bring these years into line with the total sample.

Results Bearing on the Factor Loadings of the Spatial and Quasi-Spatial Tests :

Project One

(i) Factor and correlation analyses revealed that the major factor underlying test performance was a general factor for the total group.

(ii) There was no indication of a spatial factor for the total group, although the two directional tests shared some common variance.

Project Two

(iii) Factor and correlation analyses revealed that the major factor underlying test performance was a general factor for the total group.

(iv) There was some indication of a second factor for the total group of project two. This loaded on two of the 5 subtests of the spatial test and the 2 quasi-spatial tests. It was thought to be a spatial factor though it was pointed out it did not load on the major portion of the space test.

Results Bearing on Sex Differences on Performance at the Spatial and Quasi-Spatial Tests :

Raw Score Results

As both projects had shown a heavy loading for a general factor on most of the spatial and quasi-spatial subtests, all t-tests were accompanied by analyses of variance on which the measures of g was covaried out.

(i) Project One - in general no sex differences were shown for the spatial and quasi-spatial subtests.

(ii) Project Two - sex differences were shown on 3 of the 5 spatial and both quasi-spatial tests in favour of boys for the year groups considered together.

Correlation and Factor Analyses

(iii) There was less evidence for a spatial factor for girls than for boys in both projects.

(iv) For both projects, the intercorrelations of the spatial and/or quasi-spatial tests were lower for girls than they were for boys.

Developmental Trends in Sex Differences on Spatialibility

(i) Project two - sex differences did not appear on the space tests and the quasi-spatial test of visualization before the fourth year: no differences being shown on these tests for the first three years.

(ii) There was a less consistent increase of score with age on the spatial tests of project two for girls than there was for boys.

Variables Modifying Performance on Spatial Tests

(i) Girls profited more by experience of the test material than boys did.

(ii) Artistic interest and ability were shown to be associated with superior scores on the spatial and/or quasi spatial tests of both projects.

(iii) Arithmetic ability was shown to be associated with ability at the embedded figure test in project one.

(iv) Certain interests were shown to be associated with the spatial and quasi-spatial tests of project two - dressmaking for girls; woodwork/model-making/lego/meccanno for both sexes; chess for both sexes.

(iv) Girls who wanted to make careers in architecture/draughtsmanship/design/art did as well as boys wanting to make careers in these areas even in the two oldest groups in project two.

(v) Girls who were more career oriented tended to get higher scores on the spatial and quasi-spatial tests of project two.

Instability of Sex Differences

Throughout both projects various results were obtained which pointed to the instability of sex differences in studies utilising small samples.

(i) The boys in project one obtained significantly higher scores on the measure of *g* than the girls. The reverse held for project two.

(ii) Sex differences in favour of boys were shown when the longitudinal sample was tested in the last year of the primary school on two tests. On two precisely analagous tests no sex differences were found for these children when they were tested the next year as part of project two.

(iii) In pattern copying by drawing, the primary 4 sample tested showed a sex difference in favour of boys. No difference was shown on the same test for the primary 3 sample tested.

(iv) In the first administration of the Moray House Space test, the control group (n = 49, mean age 14.8 years) showed a sex difference in favour of boys. The experimental group (n = 55, mean age 14.8 years) who were of the same age and drawn from equivalent classes, showed no sex differences on the comparable administration.

In the two final chapters, I will try to synthesize these findings both with the discussions in the preceeding chapters and with the literature in this area.

CHAPTER NINE: SEX DIFFERENCES IN STYLE

Introductory Note

In the last five chapters I have presented the results of my two projects and discussed these in some detail. In the last two chapters of this study I would like to draw the threads together. In this chapter I would like to consider the question: Can we explain sex differences on spatial test performance by references to sex differences in style?

I shall for the moment continue to refer to 'sex differences on performance at spatial tests'. It will be remembered that in Chapter 5 (pp 261 - 262) I concluded that evidence for one or more clear spatial factors or abilities was not very strong. This, of course, makes the task of defining spatial ability extremely difficult and I shall return to this difficulty and then to the related difficulty, to which I have not yet explicitly referred, the distinction between spatial and quasi-spatial tests.

Following this, in the last chapter, I shall return to the five summary points that emerged from the literature on sex differences in spatial test performance (pp 20 - 21) and I will relate these to the findings of this study. The reformulation of these points will lead to a re-examination of some of the theories that attempt to account for sex differences in spatial test performance. Finally, I will propose an interactionist theory to account for these.

Sex Differences in Style

A. The Work of Witkin

Witkin has proposed that people differ along a major psychological dimension - that of differentiation (Witkin *et al*, 1962; Witkin and Berry, 1975). By this he means that some people have a high degree of specialisation within their psychological sub-systems[1] whereas others have a lesser degree of specialisation. The more subsystems the individual has, the more separate (and therefore differentiated) are his psychological functions.

1. Those individuals who have a high degree of specialisation within their psychological sub-systems are seen as more likely to do well at spatial tasks because of their superior ability to abstract and subsequently reintegrate the components of these tasks.

Thus an individual who is highly differentiated will be aware of more attributes in a given situation than a person who is less highly differentiated. In the perceptual field the former will be inclined to be more analytical in his approach, whereas the less highly differentiated individual will be more global in his approach. In the cognitive field the more differentiated individual will have more success with 'that particular class of problems which, to be solved, require that some critical element be taken out of the context in which it is presented, and the problem material re-structured so that the item is used in a different context' (Witkin and Berry, 1975, p 5) than the less differentiated individual will. Similarly in the domain of 'nature of self' (<u>ibid</u> p 6) the more differentiated individual will have a stronger sense of identity - he will be more aware of 'a structured network of attributes identified as one's own self and as distinct from the attributes of others' (<u>ibid</u> p 6).

People are consistent in the degree to which they are differentiated - thus if an individual is highly differentiated on a perceptual task, he is likely to be highly differentiated in other areas too. Compared to less differentiated people, he is more likely to succeed in analytical cognitive tasks, he is more aware of his body, more aware of his own viewpoints and less dependent on the views of others, less likely to engage in 'massive repression' (ibid p 7) and more likely to have specialised defense structures for the regulation of impulse.

Measures of differentiation can be based on any area of psychological functioning because of the internal consistency in the degree to which human beings are differentiated. The major measures used by Witkin to measure differentiation are the embedded figure tests (EFT) and the rod-and-frame tests (RFT) (see page 10) It is, of course, acknowledged by Witkin that these are primarily perceptual tasks but they are seen as sampling, both validly and reliably, the level of differentiation. The more field independent responses are to these tasks, the more differentiated the individual making them. Thus success at EFT lies in the individual's cognitive and emotional life-style - the more articulated or differentiated his response systems, the more likely he is to see the hidden simple shape, in the complex one (See pp 565- 70 for examples of EFT items). Similarly in the rod-and-frame test the more accurately the individual sets the rod to vertical, the more field independent he is and therefore the more differentiated he is.

The origins of differentiation lie in early socialisation[1] - the more a child is trained to be objective, analytical and independent in his thinking, the more differentiated he becomes. Thus certain societies tend, according to Witkin and his co-workers to produce as a whole more differentiated individuals (I have already discussed this in Chapter 2, pp 24-26). With respect to sex differences, as I noted in Chapter 2, Witkin sees the socialisation patterns in the West differing for the two sexes in a way that predisposes girls to be less differentiated. This is because they are less likely to be encouraged to be independent, analytic and objective than boys are.

Because Witkin sees most tasks regarded as spatial as tests of field independence, he suggests that sex differences on these are explicable in terms of his theory. However, if it is accepted that individual (and therefore sex) differences in the field of independence predicate individual and sex differences on spatial tasks and on EFT, the following corollaries should hold:

1. In his 1975 monograph, Witkin proposes as well that there may be 'genetic selection for/against differentiation', (Witkin and Berry, 1975 p 15).

(a) It should be difficult to increase scores on such tasks by training because they are not dependent on specific skills but on a total psychological style which itself is dependent on socialisation.

(b) Performance at such tasks and particularly EFT should not be related to interests unless these interests are themselves characteristic of particular degrees of differentiation. Thus the studies of Mayo and Bell (1972) and Vernon (1972) who showed a correlation between EFT and spatial tasks with artistic interests/ ability are explicable only if artistic people are regarded as highly differentiated.

(c) Patterns of intercorrelations of test batteries which include EFT and RFT should always show a factor loading on these tasks which is distinct from measures of general ability.

I have cited evidence that suggests with respect to the first corollary, that performance at EFT can be improved by training (Goldstein and Chance, 1965).

Further, Sherman (1967) cites a number of studies[1] showing that performance at spatial tasks can be improved by instruction. With respect to the second corollary, both in the works cited above and in the preceeding chapter of this study, I have documented the effect on spatial scores of both interests and specific experience. With respect to the third corollary, a number of studies (notably Vernon, 1972; Hyde et al, 1975 and Riley and Denmark, 1974) have shown that such patterns of correlation are not always shown, particularly in the case of women (where correlations between RFT and EFT are seldom even significant, see Siann, 1970 and Thornton and Barrett, 1967).

The above discussion, which is based on the evidence cited in chapters 4 - 7 of this study, seems to present certain difficulties to Witkin's explanation of both individual and sex differences on

1. For example, Brinkman (quoted by Sherman, 1967) coached an experimental group in visualization and estimation and found an improvement significant at the .001 level when compared with controls in the DAT space relation test and Blade and Watson (also quoted by Sherman) found after a year of engineering studies that gains for engineering students were significantly greater than gains of controls on a spatial relations test. (Neither of these studies partitioned data for sex).

EFT and other tasks of a spatial nature. However, in Chapter 2 I made rather more general criticisms both of the measures he uses and of the theoretical aspects of Witkin's work. It will be recalled that the following three areas of difficulty were explored:

(a) That the rod-and-frame test is not a reliable measure (see pp 28-31 for relevant studies).

(b) That responses to the rod-and-frame test are affected by specific factors[1] associated with the test administration (see p 31 for relevant studies in this area).

1. Particularly with younger subjects. Both Morell (1975) and I myself (1972) have questioned whether the nature of the task is always clear to the subject. As Morell puts it: 'Is the field dependent person fooled or is he confused?' (p 102). Witkin would answer that he is fooled (being dependent) by the context into moving the rod more in line with the frame than to truly vertical. My own evidence suggested very strongly that subjects were not clear about the demands of the task, though I followed the standard instructions. But the existing literature about this subject shows what Morell calls (ibid) 'a profound ambivalence'.

(c) That the concept of field independence is increasingly questioned both on theoretical grounds and as lacking sufficient empirical backing[1] (see pp 31-34 for studies in this area).

In summary, then, I think it must be concluded that Witkin's theory, powerful and original though it is, is marred by both internal inconsistencies and technical difficulties. With particular reference to sex differences on spatial tasks, it has difficulty in accommodating to empirical data.

1. I would like to take Keogh's work as an example of the many studies that have been based on field independence. It will be remembered that her one study (with Ryan, 1971) used only 44 subjects and that in the second (1971) much stress was laid on data that was subjective and unquantified (see pp 200 - 205 of this present study). Furthermore, in this latter study only 5 of 9 t-tests showed significant sex differences in the direction she specified (1971, p 30).

B. Sex Differences in the Test Situation

This study has been concerned with an extremely narrow range of human functioning:performance at spatial tasks. But within this narrow field it has focused on sex differences and these can never be isolated from the social world. From the early seminal anthropological work of Margaret Mead (see eg 1950) to the more recent structural analyses of sociologists such as Oakley (1974) many studies have shown how society is what Ullian (1976) calls a 'prime determinant of masculinity and femininity' (p 26). In this section I shall suggest that sex differences on any task must always be viewed in a social context. Presuming, for a moment, that it had been firmly established that sex differences in performance at spatial tasks were clearly related to basic physiological differences, it would still be legitimate to enquire whether such differences at spatial tasks were not further amplified by differential expectations and experience for the sexes. I have suggested in Chapter 7 that there clearly is a role for these latter variables. However, there are bound to be other, less measurable, influences at work. Clearly the growth of sex-role identity must affect how girls and boys construe the demands of any test situation.

Much work tends to suggest that, particularly in the United States, girls, as they grow older, value academic achievement rather less than social success. Quite clearly this does not apply to those girls who have early set their sights on academic careers but these form a minority and the data relating to sex differences that have been reviewed in this study have not focused on the intellectual elite of either sex. Kipnis (1976) summarising the work in this area writes: 'While there are many ambiguities in interpretation of the usual kind of data reported...., it appears that adolescent and young American women refrain from flaunting their intellectual triumphs, and that in so doing they are responding to real, not illusory social pressures.' (p 110).

It is my contention, then, that sex differences in performance at spatial tasks should be viewed within the context of sex differences on cognitive tasks in general and also within the context of developmental trends in gender concepts. I am going to try and show that evidence from both these areas supports the hypothesis that an important influence on sex differences in performance may lie in the demands, both explicit and implicit, of the test situation.

I will first discuss the proposition at some length (pp 351 - 358) and then show that data on cognitive tests and on developmental trends in sex differences provide some backing for the proposition (pp 359-363).

Witkin's theory just reviewed is what I would term a macro-theory. He tries to fit all aspects of human functioning into his model of human differences. Such theories are, I think, less popular in the seventies than they were a decade or so before. Social psychology has influenced the field of individual differences. Many studies have shown that human behavior is often very strongly influenced by situational dynamics. In particular Zimbardo's[1] famous study of the simulated prison situation (1974) and Milgram's (1964) of obedience, have revealed the extent to which manipulation of situational variables can mould behavior. Psychologists are more inclined to ask how the subject construes the demands of any test or experiment and they are more inclined to consider how these demands, once construed, are filtered through the self-concept, (Aronson, 1976).

1. In which undergraduates placed in a simulated prison situation rapidly fell into stereotyped behavior patterns - the 'guards' becoming authoritarian and bullying and the 'prisoners' cowed and submissive. Yet before the experiment started no personality differences between the two groups were displayed - indeed they had been randomly assigned to either condition.

I suggest that sex differences in test performance may be related to such considerations. Do the two sexes construe all test situations similarly? Or are particular tests seen as more intimidating by one sex or the other? What are the differential implications for the sexes in doing well at the test situation? Does doing well at tests tie in better with male than female gender expectations? Instrumentally do men expect to profit more from doing well at tests than women do? These are some of the questions I would like to consider.

Unlike Witkin, I would not argue that a generalised cognitive style predicates all areas of human functioning; thus implying that the analytic (or differentiated in Witkin's terminology) individual always functions analytically. Instead I would contend that each situation has its specific demands and these are construed differently by different individuals and then related to their own particular self-concepts. Turning to sex differences, I would suggest that the differing socialisation imposed on the sexes makes females, particularly after adolescence, less confident in certain test situations and furthermore, less motivated to do well. As I have already mentioned, I think that evidence to support this is available from two sources - shifting patterns in cognitive test sex differences[1] and the amplification of these with age. Before reviewing this evidence I would like to discuss how the implicit and explicit situational demands may affect test performance.

Let us consider an adolescent girl who wants to make herself a dress. Let us assume that she has some considerable experience of this, having sewed for herself for a few years. She chooses a floral design for her material and then buys a fairly complicated pattern. Her first task is to understand how the component parts of the pattern fit together to form a whole. Surely a task closely related to French's definition of spatial visualisation (p 133). Then she has to organise these parts onto her length of material in such a way that the floral design matches at the interfaces of seams. Again a task that can be related to spatial orientation as defined by French (see p 133). She may do this at home, listening to the radio, in the confident expectation of completing the task successfully and in the pleasant glow of anticipation of the finished garment.

1. By shifting I refer to the inconsistencies over time in the direction of sex differences on cognitive tests.

The following day the same girl who is a very mediocre student is asked by a researcher to do a spatial task. She is faced with abstract shapes of unfamiliar aspect and reminded that she has only a limited amount of time to do the task in. Looking around the class, she may exchange glances with her boyfriend and indicate to him that she does not take any such demand by the school too seriously.

Such a comparison of the two task demands that we consider her boyfriend as well. Like his girlfriend's dressmaking, he too has a hobby - that of making model airoplanes. In the test situation he may therefore find the geometric shapes of the space test rather more familiar because of his hobby and because he has attended technical drawing classes and is familiar with two dimensional representation of geometric objects. Further the test may contain items (eg the motor boat of the G-Z spatial orientation test, (pp537 -542) that are more akin to his interests. He may also experience more need-achievement in the situation to the extent that if he construes the task as something that it is appropriate for boys to be good at, he may wish to do better at it than his peers (McClelland et al, 1953).

In sum then, I am suggesting that as boys grow older, much of their experience tends to be relevant to spatial tasks whereas for girls rather less of their day to day experience is concerned with relevant spatial experience. Hutt has shown (1975) that boys are more likely to play with mechanical toys than girls are. As I have already mentioned boys spend more time than girls in 'aiming activities and games, model construction, building with blocks and later with other materials'(Sherman, 1967, p 295). In the exploration of mechanical and constructional toys, boys are thus likely to build up an approach to visual shapes that will stand them in good stead when it comes to the spatial components of standard spatial tests. Girls, on the other hand, are less likely to handle and explore the components of constructional and mechanical toys. In dressmaking they may gain a limited familiarity with visual shapes but I would argue that they are likely to see the spatial skills they use in this pursuit as linked to the specific task they are engaged in and are unlikely to integrate these skills into a general view of 'how things work' and more importantly into a view of how components of three dimensional material 'fit together'.

This view is shared by Sherman (1967). In her discussion of Inhelder's (see eg Tanner and Inhelder, 1958) approach to spatial representation, she notes that the latter sees the mental image in its spatial form as springing from the interiorisation of the movements of exploration. If, as it is commonly accepted (see Hutt,[1] 1975A), boys are more likely to engage in exploratory activities, then the precursors of a difference in approach to spatial tasks can be seen.

To return to the girl who is good at dressmaking, I argue that the girl, though quite capable of solving the complicated spatial demands of her hobby, is unlikely to mobilise these skills in a spatial task because she sees no connection. Whereas her boyfriend, who from early childhood has been accustomed to considering how things fit together and how things work, will integrate this viewpoint and experience into his performance at the spatial test.

My second point is that girls are less likely to be positively motivated to do well at spatial tasks. This hypothesis can be

1. Hutt (1975A) has suggested that boys, from an early age, are more 'thing-orientated' whereas girls are more 'person-orientated', (p 163).

linked to the work of Horner (1970). She has suggested that in America women are sometimes motivated by a fear of success and that this makes them less likely than men to perform at their optimum level at certain cognitive tasks. She claims that many people unconsciously connect sex with certain characteristics and occupations. Women are for instance not expected to be physicists and for a woman to excel at this task may pose a threat to her concept of femininity[1].

Certain criticisms of Horner's experimental work have been voiced (see for example, Tresemer, 1974) but these, while querying whether fear of success is a motive in the sense that McClelland (1953) uses it, have not thrown substantial doubt on her major contention that western women feel ambivalent about achievement in male dominated spheres. Indeed Tresemer himself notes that perhaps her 'fear of success' motive could be replaced by a 'fear of sex-role inappropriateness' (Tresemer, 1974, p 85)

Thus, I would argue that the inconsistent rise with age in girls' scores on spatial tasks can be related to their growing awareness

1. Coleman (1961) found that girls believed boys did not want to date scholarly, intelligent girls.

of what is and what is not, in Tresemer's term, 'sex-role appropriate'.

Some relevant evidence to spatial tasks comes from a study by Sandström and Lundberg (1956) using a task that involved stimuli similar to those used in spatial tests. They noted in discussing sex differences on a pin location task (p 252): 'Sandstrom's adult female Ss participated more spontaneously in the experimental situation, they accepted the instructions more unreflectingly and in general, adopted a more passive attitude to the task. As a rule the male Ss were more suspicious and wondering and usually required more time to make their decisions.' Not surprisingly the males obtained higher scores, clearly they were more task oriented where the females were merely conforming to the demands of the experimenter, as they saw them and were not particularly interested in the task <u>per se</u>.

This discussion has suggested that sex differences in performance at spatial tasks cannot be viewed without reference both to the early socialisation patterns of boys and girls and to the stereotypes our society holds about sex appropriate behaviour. In addition to this general discussion, however, I think certain empirical findings point to the importance of taking social pressures into consideration. The findings can be grouped into two areas and I shall consider each of these in turn. They are:

(a) The shifting nature of sex differences on cognitive tasks.

(b) The amplification of sex differences with age.

(a) The shifting nature of sex differences on cognitive tasks

Kipnis (1976) has reviewed a number of studies that show that whereas in the earlier part of this century, women tended to score higher on I.Q. tests than men, more recently the trend has been reversed. For example, the earliest normative data on the Weschler-Bellevue scale obtained from some 1700 individuals showed a slight but positive difference in favour of females (Kipnis, 1976). Further, the longitudinal study by Bradway and Thomson (1962) of 111 subjects on the Stanford-Binet showed a superiority for females over 30 years.

More recent studies, however, have shown a superiority in favour of males. Thus the 1955 standardisation of the Wechsler showed a shift in direction for a number of sub-scales that had previously showed a superiority for females (Kipnis, 1976). Furthermore, Newcombe <u>et al</u> (1975), in a study of 928 adults in Oxfordshire villages showed a consistent difference on the WAIS in favour of males, on both the verbal and the performance scales.

How are we to reconcile these differences? Kipnis (1976) has suggested that whichever sex is afforded the greater educational advantages is likely to prove more 'intelligent' on testing. She shows that in the earlier part of the twentieth century, women equalled or indeed exceeded men in years of education but with positive discrimination in favour of men at the end of the second world war, the position changed and an educational differential was set up which favoured males. Her data is American but the conclusion drawn seems equally valid for other societies. 'Intelligence as we know and measure it, is a result of a continuing interaction between individuals and an environment which affords opportunity to learn' (p 103).

Looking again at the DAT norms (Bennett <u>et al</u>, 1968) these show as I have noted that male superiority by the 11th or 12th grade is established on numeric ability and verbal reasoning as well as space relations. However, males are not superior on all the tests of the DAT battery. As Fairweather noted, (1976, see p 12 of this study), there is no difference on tests of abstract reasoning. Thus it would not seem that sex differences on the DAT battery are due to the fact that the older girls are less logical. The DAT norms also show that females are superior on spelling, grammer and clerical speed and ability, so it does not seem that girls are less motivated in general. It would appear, then, that sex differences on the DAT battery are not easily ascribable to a sex difference on a single underlying dimension.

Academic achievement records show the same confused picture. In America, girls are better in later adolescence at writing ability but not at social studies and citizenship (Forbes, 1975, talking about the American study conducted by the Education Commission of the States of 900,000 students). In this country, girls excel at languages and religious studies and boys at science and mathematics (Clwyd, 1977). Why should girls excel at religious studies in Britain but do comparatively badly at citizenship in the United States? It would not seem that a biological explanation could account for such differences nor for the shift in direction on intelligence tests that I have just reviewed. I think it must be concluded that sex differences in both academic achievement and on psychometric tests are not easily explicable in terms of a single unitary variable, such as analytical ability or spatial ability[1], but are more likely to be a shifting response to complex pressures within the society that manifest themselves not only in stereotypes about what girls and boys should be good at but also in educational opportunities and vocational patterns.

(b) Amplification of Sex Differences with Age

I have quoted data to show that sex differences on some of the DAT subtest and on certain tests of a spatial nature amplify with age in favour of males (Chapter 6). However, what I have not thus far discussed is that there is a tendency for female scores on intelligence tests to show less increase with age than males do. In the longitudinal study I have already cited by Bradway and Thomson (1962) of 111 subjects, the females over a period of 30 years

1. It could be argued, for example, that the superiority boys show at mathematics and physics (Clwyd, 1977), is mainly due to their superiority at spatial skills. On the other hand, it is hard to see how their superior spatial skill could be used to account for boys' superiority at biology and chemistry (Clwyd, 1977).

consistently scored better than the males but the males showed more increase in I.Q. after adolescence. Further, Campbell (1974) who compared the I.Q. scores of 473 subjects both before and after adolescence found that boys experienced a gain in I.Q. scores while girls experienced a decline. It is difficult to understand these longitudinal studies unless we assume that after or during adolescence females experience a decline in motivation in the I.Q. test situation or else are subjected to a different environment, physical or individual, which is less favourable to the stimulation of intelligence as measured by intelligence tests.

It seems to me that the inconsistent increase of test scores with age, whether these be on the space tests, reviewed in Chapter 6 or on I.Q. as in the two studies just quoted, point unambiguously to the role of non-cognitive factors in the test situation. Unless one is to propose an atrophy in the brain of women that occurs simultaneously with the onset of adolescence, it seems difficult to ascribe the actual decline found by Campbell to anything other than a reaction by the girls to the demands of the test situation. As they grow older, their need to do well in the test situation would appear to decrease. However, as the DAT data showed, this motivational change does not extend to all tests. As I noted, the increase in scores on certain tests continues (p361). On the DAT battery, girls continue to outstrip boys on clerical and certain varbal skills. It seems to me that the conclusion we arrive at is similar to the one drawn at the end of the sub-section on the shifting nature of sex differences on cognitive tests; sex differences are at least partially a response to societal pressures.

In summary then, I have suggested that some sex differences in style may apply to the test situation. Because girls show a less consistent increase with age on certain cognitive tests and in some cases actually decline, I have inferred that there may be a drop in their motivational level as they grow older. Their sights are no longer set on the schoolroom but on the work situation. Thus, clerical skills and writing skills may still be regarded as important but the more abstract and less clearly relevant nature of I.Q. and Space tests may generate very little interest. Whereas boys may see the space tests at any rate, as relevant to their interests and appropriate to the masculine sphere of interest. Even if this analysis is too speculative in detail, I have argued that the nature of sex differences on test scores does not lead one to infer that there is a single unitary cognitive trait producing these differences but points rather to a complicated set of responses to the values and gender stereotypes of the societies concerned.

C. Sex Differences in Approach to Spatial Tasks

In the last section I suggested that the actual test situation may generate sex differences in adolescent subjects. Girls may be more 'signed off' tests that have items of abstract, geometric and technical nature and also may be less likely to mobilise relevant skills than boys are.

In addition, it could be argued that the lack of consistency shown in girls' test scores on spatial tests, may point to a difference in technique for the sexes. If certain tests are amenable to verbal or non-spatial symbolic solution, are girls more likely to use these techniques than boys are? It will be remembered that in Chapter 4 I showed, both by reference to the Marmour and Zaback (1976) study with blind subjects and to the coaching techniques used in my own study, that certain items could be solved with reference to verbal techniques. In addition, McCall (1955) found that eighth grade girls were more likely to use verbal ability in tests of spatial perception than boys were.

An anecdote may supplement this point. One female psychologist, on being shown the DAT space relations test (Appendix VIII, page 553) responded that she would certainly approach it by working out the symbolic relations of the component parts rather than by spatial techniques, i.e. with reference to item 1 p. 4 'only two sides of the box are dark and these are opposite, therefore D for instance can't be right because it has two adjacent dark sides.'

If it is the case that there is a sex difference in approach to tests of a spatial nature then this may account for the conclusions drawn at the end of Chapter 5 that different sub-tests appear to load differently for the sexes, on respectively the g factor and the remaining factor or factors (pp 238 - 242).

I have already noted in this chapter (5) that the existence of a clear and unambiguous spatial factor was less clear for girls than boys. Not only did my data indicate this but Vernon (1972) has drawn the same conclusion (see p 261 of this study). His conclusion is drawn from a study of 200 representative A.T.S. recruits

(1961, p 119) in which one interpretation of the data would seem to point to the fact that spatial-mechanical tests measure hardly anything but g for women. Unfortunately his 1972 study did not partition the appropriate data for the sexes but Hyde et al (1975) in their study reported a less clear-cut spatial factor for females than for males.

I would suggest therefore that another difference between the sexes that may affect performance at spatial tests may lie in the varying approach the sexes may bring to such tasks. In Chapter 5, I suggested a difference in what I called nous, that is, that when boys approach a spatial task they are more prepared than girls are to relate it to other relevant experience, they are less likely to rely on, say, verbal strategies and are more prepared to seek the solution by manipulation of the spatial rather than the symbolic relationship of the component parts.

In the next chapter I shall enquire whether this latter difference between the sexes can be ascribed a biological origin. But for the moment I would like to sum up the differences in style that I think characterise the sexes in their approach to spatial tasks:

(a) The two sexes approach the test situation with varying degrees of motivation - spatial tasks are seen more as a masculine than a feminine province, particularly at and after adolescence.

(b) Boys may see other appropriate experience as more relevant than girls do.

(c) Boys may be less inclined than girls to rely on verbal strategies to aid in the solution of spatial tasks.

(d) For boys, the tasks may seem less isolated from their general understanding of the world - they are accustomed to handling mechanical devices and more exposed to model making and woodwork. In general, they are more accustomed to thinking about three-dimensional objects and thus in the solution of spatial tasks they may call on more areas of relevant experience than girls do.

Defining Spatial Ability and its Relationship to Sex Differences on Spatial Tasks

At the simplest level, noting sex differences on spatial tasks, one may ascribe these to differences on spatial ability. Indeed some of the theories[1] reviewed in Chapter 2 make this assumption.

1. For example, Buffery and Gray's theory on hemispheric differences (1972) and Stafford's (1961) theory that spatial ability is carried on a gene on the X chromosome.

But this study has demonstrated that the existance of such unambiguous ability or abilities is not clear-cut. In Chapter 5 I noted the following five points which must be taken into account when attempting to define spatial ability:

(a) That such ability has more than one component.

(b) That these components do not seem easily characterised as 'spatial orientation' and 'spatial visualization'.

(c) That such components do not seem to relate in a straightforward manner to two versus three dimensions.

(d) That labelling a test 'spatial' does not guarantee that it is a valid measure of spatial skills - though consisting of spatial stimuli it may load mainly on g (see eg MS 1, Tables 15C and 41).

(e) That a test may have differing components of g and spatial skills for the two sexes.

Thus defining spatial ability proves to be rather a difficult task and the dearth of definitions noted in Chapter 4 (pp 120 - 122) becomes readily understood. Even the operational definition I started off with becomes less than satisfactory. This stated that spatial ability is 'that which is measured by tests regarded as spatial'. As it has now been shown that items commonly regarded[1] as spatial and included in many spatial batteries load mainly on *g*, this definition is not acceptable.

Defining Spatial Ability

Perhaps spatial ability can be more realistically defined as follows:

A generic term covering a range of skills concerned with the manipulation of visual images.

Four points attach to this definition:

(a) The skills concerned are correlated with each other in varying degrees depending on the group of subjects tested. From the data of this study as well as from studies by Vernon, 1972; Hyde et al, 1975; Yen, 1975B; Thornton and Barrett, 1967, it would appear that the skills are more positively correlated for males than females.

1. I refer to items represented by the sub-test MS 1 (see Appendix VI) which require the subject to choose one of a number of stimuli which could represent the rotation of a two dimensional abstract shape.

(b) Such skills are by no means fixed for any subject. It would seem that relevant experience and motivational factors can modify performance on tests concerned with these skills (Chapter 7).

(c) A test of 'spatial ability' can then be seen as a test that measures at least one spatial skill - ie, requires the subject to perform at least one type of manipulation of visual images. It may also measure general ability and motivational level (Chapter 4).

(d) Techniques for solving the items of spatial tests may differ. Subjects may utilise verbal and symbolic strategies in their solution as well as solutions relying only on the visual properties of the stimuli (Marmour and Zaback, 1976; Vandenberg, 1969).

The Distinction between Quasi-Spatial and Spatial Tests

On page 8 I noted that certain tests not originally designed as tests of spatial ability are often quoted in the literature as measuring spatial skills. Throughout this study I have referred to these as 'quasi-spatial' tests.

It would seem that since there is neither strong evidence for a single unambiguous spatial factor, nor the prospect of ever producing a test that will measure spatial skills to the exclusion of everything else (points (c) and (d) above) all spatial tests probably vary along a continuum in the extent to which they are measures of mainly spatial skills. Further this place along the continuum is not fixed for all groups of subjects. To take a concrete example, students who have studied solid geometry and in particular nets of three dimensional objects, will obviously find the DAT space relations test easier than subjects with no such experience. Further, the former may be more inclined to rely on mathematical analyses than the latter.

We can therefore perhaps regard the quasi-spatial tests such as Keogh's pattern copying as lying at the end of this continuum - clearly some manipulation of shapes is involved but so are many other variables - drawing ability, motivation and with younger children in particular, general intelligence[1]. Other quasi-spatial tests will be more or less 'spatial' depending on the subjects. For example, in the EFT, artists may utilise skills analagous to those they use in the composition of their pictures. Certainly these skills are 'spatial' in that they involve the use of shapes related to an overall field but they may be very poorly correlated

1. Using this term in the sense discussed in Chapter 4, pp127 -128.

for example with the skills making for success in Guilford-Zimmerman spatial orientation test. Reference to this test (Appendix VII, page 537) will indicate firstly that a high degree of verbal ability is required to understand the instructions. Once this is done, the examples may be done by means of a purely verbal rule: there are three parameters - movement horizontally, movement vertically and slant. Comparing the first picture to the last, negate all movement, ie, if the target has shifted to the left, shift right; if it has shifted up, shift down, and change direction of the slant.

In summary then, any test that utilises visual shapes may call on some spatial skill or skills for some, but not necessarily all, subjects. Whether such a test is to be labelled a test of spatial ability probably depends on the designer as well as the target subjects. Perhaps some tests are more validly measures of spatial ability for all subjects than others, but unless such tests are administered within a battery that contains at least one measure of general ability, we cannot be sure of the extent to which a spatial skill or skills load on it for the subjects concerned.

CHAPTER TEN: ACCOUNTING FOR SEX DIFFERENCES IN PERFORMANCE AT SPATIAL TESTS

Introductory Note

In this chapter I should like to re-examine some of the theories presented in Chapter 2 which have been put forward to account for sex differences on spatial tasks. In doing so I will only consider three of the theories because I showed in Chapter 2 and Chapter 9 for Witkin's theories that the remainder were either based on inadequate empirical data or displayed inconsistencies. The theories I will concentrate on are:

Social Conditioning. Theory two: Differential expectation and practice.

Biological Determinism. Differential lateralisation for the sexes. Theory two: High spatial ability is related to right hand processing of spatial tasks.

Biological Determinism. Theory three: Sex differences in spatial ability are governed by a recessive gene.

These theories will be reconsidered in the light of the reformulated points arising from the review of the literature (Chapter 1) and the results of this study (Chapters 4 - 9). Finally I will propose an interactionist theory to account for sex differences in this area.

Reformulating the Summary Points on Sex Differences on Spatial Tasks

In Chapter 1, I concluded that the survey of the literature yielded five summary points and I suggested that any theory postulated to account for sex differences in spatial ability should be able to account for them. The five points were:

Consistent sex differences in favour of men are shown for:

1. Adults on tests specifically designed to measure spatial ability, (eg, the Guilford-Zimmerman tests and the DAT).
2. Children older than 13/14 years on standardised spatial tests. These differences appear to increase with age mainly due to the fact that girls' scores tend to remain static or decline while boys' scores improve.

With respect to the other tests discussed, ie, tests of field independence and those not specifically designed to measure spatial ability but regarded as having a high spatial component (henceforth to be referred to as 'quasi' spatial tests) findings are not so clear cut:

3. On tests of field independence and on 'quasi' spatial tests men in the West tend to do better than women though this finding is not consistent.

4. On tests of field independence and on 'quasi' spatial tests children do not show sex differences that are at all consistent.

5. On tests of field independence and on 'quasi' spatial tests non-Western adult populations do not show consistent sex differences.

I would like to re-examine these points in the light of the discussion in the preceding five chapters. Clearly point two has been confirmed by my own results. Sex differences in this area only appear around 14 years of age, and girls' scores show a less consistent rise with age than boys' do. My results have given no reason to dispute point one - sex differences in favour of males for adults. Thus these two points remain unchanged.

Points three and four deal with sex differences on tests of field independence and on quasi-spatial tests. My results have indicated that the test of field independence I used (EFT) and the quasi-spatial tests I used were highly loaded with *g*. In view of the fact that sex differences in *g* have been shown to be inconsistent, inconsistencies in sex differences on tests of field independence and on quasi-spatial tests can be ascribed to these findings and need not necessarily be related to sex differences on spatial skills. There is thus no need to retain points 3 and 4.

The last point dealt with sex differences in the cross-cultural setting. Once again, as with the two preceding points, I would refer to the fact that the tests used in this setting have been of the type that I have showed to be heavily saturated with *g*[1] and the inconsistent sex differences become explicable in terms of this. Thus I will not retain this summary point.

Aside from the two points retained from the original five, the following two points have emerged from the results and discussion of the preceding chapters. Firstly that intercorrelations for spatial tests are lower for females than for males (Yen, 1975B;

1. With the possible exception of the Morrisby shapes used by Berry (1955) see p. 19.

Vernon, 1972; Siann, this study). Secondly that spatial ability has not been shown to be a clear and unifactorial ability, but is more appropriately seen as a number of skills that vary in the degree to which they are interrelated for different groups of subjects. (Hyde et al, 1975; Siann, this study)

Relabelling the relevant points[1] and breaking up the second into two sections we have:

(A) Consistent sex differences in favour of males are shown for adults in performance at spatial tasks.

(B) Consistent sex differences in favour of males on performance at spacial tasks are shown for children over the age of 13-14. No sex differences are shown before this age.

(C) Female scores on spatial tasks show a less consistent rise with age than males scores do.

(D) Intercorrelations between spatial tasks are lower for females than they are for males.

(E) Spatial ability has not been shown to be either unifactorial or composed of clearly identifiable and unambiguous factors.

1. In order to avoid confusion with the original five.

Re-examining Three Theories in the Light of the Reformulated Summary Points

1. Differential expectation and practice

This theory was presented on pp. 34 - 39 of Chapter 2. It sought to relate sex differences on tests of spatial ability to social variables. It was suggested that males approached spatial tasks with both more relevant experience and greater motivation. The theory was shown to accomodate the empirical data well at that stage but it was felt that it was too speculative and lacked sufficient rigorous testing of specific hypotheses.

One of the main objects of this study was to investigate some specific hypotheses arising from the theory. (See aim (e) p. 87.) For example the effect of relevant past experiences and interests on spatial scores was considered. In the main, the hypotheses received support (Chapter 7). Performance on spatial tests was shown to be related to artistic interests/ability, experience with three dimensional toys and woodwork, vocational aspirations for girls and commitment to a career for girls. On the other hand though significent associations were shown for relevant interests and experience no association was shown for another hypothesised variable - sex of experimenter.

It was also argued that sex differences on spatial tasks showed a very similar pattern to sex differences on other cognitive tests for example both reasoning and numerical ability (Chapter 7). In addition the inconsistent rise on spatial scores with age for girls was shown to be similar to the inconsistent rise on I.Q. scores with age (Chapter 9). It was concluded from these similarities that sex differences on certain cognitive tests may be a response to the stereotypes of masculinity and feminity rather than to any one underlying variable. The concept of differing test styles was put forward to account for sex differences in spacial tasks. Boys were thought to have more spatial <u>nous</u> - to approach spatial tasks both in a more motivated manner and more prepared to relate the tasks to other relevant experience. Girls, on the other hand, it was suggested, were more likely to treat such tasks in isolation from their other interests and experience.

The theory accomodates the reformulated summary points (page 378) well. Point A, the consistent superiority shown by male adults on spatial tasks was related to the more appropriate interests and experience they brought to such tasks. It was argued that in fact there was a difference in style between sexes in their approach to such tests. It was suggested that males were more likely both to have more relevant experience and to relate such experience to the tests. Some support was offered from the data of project two in that exposure to the test a second time was of greater benefit to females than to males.

Point B dealt with the lack of sex differences on spatial tasks before the age of 13-14. The theory accomodates this by postulating that this finding can be related to the slowly accumulating effect of both differential practice and differential expectation and gender stereotypes. And point C the inconsistent rise in girls' spatial scores with age is also explained by the increasingly powerful effects of societal pressure. That the girls lack of increase in scores is due to a threshold effect was disputed because the coaching study (Chapter 5) had not only shown a rise in girls scores but the control groups showed a proportionately greater rise for girls' scores than boys' scores.

Point D referred to the lower intercorrelations shown by girls on scores at spatial tasks. The concept of differing styles for the sexes was used to explain this finding. Boys were regarded as approaching spatial tasks more confidently than girls were and were regarded as being able to draw on more relevant experience. Consequently it was argued that they were more likely to integrate the demands of spatial tasks into an existing cognitive grid. In contrast it was thought that girls were more likely to approach spatial tasks in a more piecemeal manner.

The final point referred to the nature of spatial ability. The theory accomodated well to the proposed nature of this. Central to the theory is the concept, that for different subjects different relationships between spatial skills would be shown. The greater the subjects' familiarity with the type of task, the more likely they would be to integrate the task demands into an already existing pool of spatial techniques.

Thus, as Table 54 shows the theory accomodates well to the empirical findings. I feel however that there are two drawbacks to this approach. In the first case more supporting data is needed before such a theory can be regarded as being well established. Some directions of further study include confirmation of the association between girls vocational aspirations and their test scores. Further replication of the findings of the coaching study are also needed.

A possible area of further study is cross-cultural. In certain East European societies women engineers and architects are more common than they are in Western societies. Is this trend accompanied by a lower incidence of sex differences in spatial tests ? Similar research in less technologically developed societies is not recommended as in these psychometric tests tend to measure mainly _g_ or educational variables (Siann, 1970).

Concepts of gender are changing. It would be interesting to compare sex differences on spatial tests for different generations and different social classes.

Finally if adequate facilities were available then a large scale longitudinal study could be used to investigate the hypotheses derived from this theory. Such a study should cover the years

10 to 20 and include in the test battery at least one measure of *g* aside from a number of spatial tasks. The battery should be accompanied by both interviews and questionnaires designed to investigate not only interests and relevant experience but also attitudes to the tests and gender concepts and stereotypes. Ideally such a study should cover all social classes and not concentrate as mine did on children from the middle and lower middle class.

Aside from the paucity of supporting studies, I feel that this theory has one other major drawback. This is that whereas this study has shown sex differences on I.Q. to be shifting both for adults and for children, sex differences on spatial ability for adults are consistently in favour of males. Does the very consistency shown not argue for perhaps an additional source of sexual differentiation of a biological origin ? I will return to this in the last section of this study.

Biological Determinism. Theory Two. High Spatial Ability is related to the Right Hemispheric Processing of Spatial Tasks

A number of researchers (see for example, Kimura, 1969) have proposed that male superiority on spatial tasks stems from the greater specialization of the two hemispheres for the male. Whereas it is thought that women are inclined to process spatial tasks bilaterally, men are thought to process them in the right hemisphere. On pp 49-53 I showed that research does tend to show that men are more inclined to process spatial tasks in the right hemisphere than women are but I pointed out that in order to account adequately for sex differences on spatial tests two linkages had to be made. In the first case it had to be demonstrated that the complex demands of spatial tasks showing sex differences were processed more often by men than by women in the right hemisphere only and secondly that high scorers on spatial tests were those who were more unilateral in their processing of spacial tasks.

In Chapter 2 I showed that this theory was able to accomodate the five original summary points reasonably well but I concluded that until the linkages described above could be made, the explanation for sex differences on spatial tasks remained speculative. (pp49 - 57) I would like now to relate this theory to the reformulated summary points, assuming for the moment that the linkages discussed above had been established.

Point A refers to the consistent sex differences shown in favour of adult males on spatial tests. Clearly the theory accomodates this.

Point B refers to the lack of sex differences on spatial tasks before the onset of adolescence. In Chapter 2 I argued that this point was not well accomodated by the theory because many researchers in the field eg.(Witelson 1976) saw sex differences in lateralisation established in early childhood. However in view of the discussion in Chapter 9 (pp365 - 7) I would like to reconsider this. In Chapter 9 I argued that as boys get older so they develop a more unified approach to spatial tasks. While I have shown that this more unified approach could be explained in terms of social variables, it could equally well be explained as follows. As boys grow older they become more reliant on right hemispheric processing of spatial tasks whereas girls as they grow older continue to process these tasks bilaterally. Sex differences may not be shown in the earlier years because at this age, skills are less differentiated (Butcher, 1970, p50), and therefore boys as well as girls will tend to use both hemispheres for spatial tests. As they grow older, boys may cease to rely at all on the left hemisphere for these tasks and so perform better in terms of the main hypothesis of the theory.

It has been suggested that certain spatial tasks can be approached using different strategies. For example in the DAT verbal strategies could be employed (see p 366). Is it possible that because females continue to process spatial tasks bilaterally they make more use of verbal techniques ? If this is the case, Point D, the lower correlations for female scores in comparison to the correlations for male scores becomes explicable in terms of the theory being considered. It can be accounted for thus. Males, because they process all (or most) spatial tasks unilaterally, do so more consistently; whereas females, make use of either bilateral or unilateral processing and will consequently perform less consistently on spatial tasks.

Point C, the less consistent increase in females scores with age is not well accomodated by the theory. Had a threshold effect for female scores been demonstrated, it might have been explicable. But in the absence of this effect (see Chapter 5, pp 229-236) this finding cannot be accomodated by this theory.

The fifth reformulated summary point concerns the nature of spatial ability. While theorists in this area tend to write as though spatial ability is a unitary factor, this is by no means a necessary part of the theory. It could be argued, in terms of this theory, that all the different spatial skills are best processed unilaterally.

In summary then as Table54 shows the theory accomodates four out of five of the reformulated summary points well. Its chief drawback lies in the lack of empirical validation in two important areas. Firstly it has not yet been shown that the complex items of spatial tests are more often processed by men than women in the right hemisphere only. And secondly it has not been shown that subjects who score highly on spatial tests are those who are more unilateral in their processing of spatial tasks.

Biological Determinism. Theory three. Sex Differences in Spatial Ability are governed by a Recessive Gene

This theory (pp 61 - 68) accounted for sex differences on tasks of a spatial nature by postulating that high spatial ability is carried on a recessive gene on the X chromosome (Buffery and Gray, 1972). The empirical evidence for this theory has been discussed on pp 61 - 65. In doing so I noted that even proponents of the theory like Yen (1975A, 1975B) acknowledge that it cannot account on its own for the observed pattern of sex differences she found in her own large scale study.

In addition, I have throughout this study, and particularly in Chapter 4, commented on the assumption underlying Yen's study (1975B). This assumption postulates that the first factor she extracted from her multiple component analysis of a test battery containing only spatial tests was a spatial factor. I have suggested that in the absence of other, non-spatial tests, such as a test of g, this is not a legitimate assumption.

In Chapter 2, I concluded that the theory accomodated the five original summary points well (see p 365-368) but in the light of the accumulating data of this study I will now show that this theory accomodates the five reformulated points less well.

Clearly the first point (page 378) is well accomodated. Men score higher than women on spatial tasks because they are more likely in terms of the theory to carry the high spatial ability allele (Buffery and Gray, 1972 pp127-129).

The second point concerns the lack of sex differences shown by pre-adolscent children on spatial tasks. Bock and Kolawowski (1973) note that this gene for spatial ability may be 'testosterone limited in its expression' (p12) however the mechanism by which this hormonal interaction takes place is not discussed. Indeed, as most evidence on the effects of hormones on psychological differentiation suggests that their long term effects are due to their presence at the later prenatal and early neonatal periods, such an interaction, at the period of adolescence, is not very likely (Archer, 1976; Rogers, 1976).

The three later points derived on page 378 are not at all well accomodated by this theory. Point C deals with the inconsistent rise in girls scores on spatial tests with age and Point D deals with the lower intercorrelations on spatial tests shown by girls compared to boys. Yen, 1975B, notes both these effects in her own study and concludes that 'If the estimation procedures used are reasonable' (referring to her analyses of the genetic statistics derived from her data) 'sex linkage is not a complete explanation of the sex differences observed' (p297).

Point C dealt with the nature of spatial ability. Bock and Kolawowski (1973) concede that there are at least two components of spatial ability (p12). The genetic component carried on the gene is seen as accounting for 46% of the score variance on their data, and the other component is not expanded upon. As I have already mentioned, neither my data nor that of Hyde et al (1975) yielded indications of such a clear spatial factor as this theory would predict but it must be remembered that both these studies used comparitively small samples.

Thus it will be seen from Table 54 that this theory does not accomodate the five reformulated summary points well. Another comment I would like to make, is that while I am a non-sophisticated reader of genetic papers, I do find some of Bock and Kolakowski's simpler statistics puzzling. In their presentation of their familial correlations, they show the highest correlation between fathers and mothers (see p62, Table 5). Surely if a genetic linkage is present, higher correlations should be shown between blood relations ? It could be argued that the comparitively high FA-MO correlations are due to the effects of assortative mating in that the more intelligent individuals would both score higher on spatial tests and tend to marry equally intelligent mates. If this explanation is used to account for the comparitively high FA-MO correlation, it could be used to argue that the children of such alliances should be subject to the effects both of the genetic contribution to their spatial scores and to the environmental effects produced by the assortative mating. Thus they should show even higher correlations with the appropriate parent (FA-DAU, MO-SON, and MO-DAU) than the parental correlation (FA-MO).

An interactionist perspective

Throughout this study I have pointed out evidence that suggests that sex differences on spatial tasks are in large degree due to social

TABLE 54: RELATING FINDINGS ON SEX DIFFERENCES ON PERFORMANCE AT SPATIAL TASKS TO THREE THEORETICAL EXPLANATIONS OF THESE DIFFERENCES

	THEORIES		
FINDINGS	DIFFERENTIAL EXPECTATION AND PRACTICE	LATERALISATION FEMALES MORE BILATERAL	SPATIAL ABILITY CARRIED ON RECESSIVE GENE
A Male adults score higher at spatial tasks than female adults	**	**	**
B No sex differences on spatial tasks shown before age 13-14	**	**	*
C Less consistent rise in female spatial scores with age	**	-	-
D Intercorrelations on spatial tasks lower for females than for males	**	**	-
E Spatial ability not clearly uni- or bi-factorial	**	**	-

** well accommodated

* reasonably well accommodated

\- not well accommodated

factors. On pp 382-84 of this chapter I showed that a social conditioning theory can account reasonably well for all the observations in this area. Nevertheless I noted that sex differences in this area for adults are so consistent, that one is led to speculate that perhaps another, more biological mechanism is also involved. In my opinion, the question could be reasonably well resolved were adequate cross-cultural data available. If in other non-Western countries, where there is a relatively higher proportion of female engineers and architects, sex differences on spatial tasks were shown to be considerably lessened or indeed non-existent, the case for social origin of sex differences in this area would be very strong indeed. In the absence of such data, however, I consider an interactionist perspective must be retained (Lloyd, 1976, and see this study page 2).

Some theorists argue that there may have been selection pressure for male superiority in spatial skills from an evolutionary viewpoint. And indeed some non-human studies suggest that males tend to show superiority in skills with a spatial dimension. For example, Buffery and Gray, (1972), argue that male rat superiority in learning complex mazes is due to superiority in 'spatial' skills and Hamburg, 1974, claims that aimed throwing of objects is a 'male behavior' for free-living chimpanzees. Hamburg argues different lateralisation patterns for the sexes may have developed because the male in early human societies needed to have high spatial ability for hunting and warfare.

Perhaps it may be concluded that there is a predisposition in the human male to process certain visual data more unilaterally than the female. This predisposition being, in part perhaps, ascribable to evolutionary demands. Combined with the societal pressures I have described on pp 379 - 381 of this chapter, this greater lateralisation of the male brain tends to produce more skilled spatial behaviour for males. That is, if this predisposition is present in early childhood, it may influence boys to select areas of experience that capitalise on their innate skills - eg. it may lead them to prefer to play with three-dimensional toys and lead them to prefer games like cricket where their skilled performance in throwing objects (Hamburg, 1976) is an advantage. On the other hand, because of their innate inferiority at such games and at motor skills involving the manipulation of shapes, girls may be drawn to more verbal and social persuits. As Western society in any case regards cricket and Lego as more appropriate to boys and reading and socialising as more appropriate to girls, there will be strong interactional effects between the biological and social causation of sex differences in the area of spatial skills.

Nevertheless, if there is an element of biological causation in sex differences on performance at spatial tasks, I do not believe it is a limiting one. There is no evidence of a threshold in female ability to do spatial tasks. Evidence cited in this study has shown that girls, over the age where sex differences appear, can score as well as boys if they are motivated. Thus the girls studied by Nash (1974) did as well at the DAT space test as boys if they would have 'preferred to have been boys'. In my study, those girls with career aspirations in areas where spatial skills would be useful, scored as well as boys.

My overall conclusion is that while some of the sex differences in spatial skills shown above the age of 13-14 years may be due to a biological cause such as differing patterns of lateralisation for the sexes, the major origin of such differences is social.

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APPENDICES

APPENDIX I.

MORAY HOUSE COLLEGE OF EDUCATION

HOLYROOD ROAD · EDINBURGH EH8 8AQ TELEPHONE: 031-556 8455

PRINCIPAL BAILLIE T RUTHVEN, M.A., F.E.I.S.

Your Reference:
Our Reference:

PSYCHOLOGY DEPARTMENT

in conjunction with

UNIVERSITY OF EDINBURGH
PSYCHOLOGY DEPARTMENT

28th January, 1976.

Dear Parent,

We are at present engaged in a research project that is investigating the link between spatial ability and aspects of mathematics, as well as every-day skills like map reading and finding one's direction.

Mr. McKenzie has kindly agreed to allow us to work with a class in each year from Grades III to VII subject to parents' approval. We would like to stress that no child has been specially selected and that no personal questions will be asked of the children.

The programme involves each child in the classes concerned spending one hour at the school, in school time, with a research assistant doing some spatial tests, e.g. mazes and pattern spotting and copying. In addition each child taking part will be asked to do one test at Moray House College of Education. For this test College transport will be provided.

We will be very happy to answer any questions from parents about the project and can be contacted at the addresses given above.

Yours sincerely,

H Beloff

Dr. H. Beloff,
PSYCHOLOGY DEPARTMENT
UNIVERSITY OF EDINBURGH

Gerda Siann.

Mrs. G. Siann
PSYCHOLOGY DEPARTMENT
MORAY HOUSE COLLEGE OF EDUCATION

APPENDIX II.

Instructions for Stage 1 Experiment.

INDEX.

Instructions for Spatial Ability Survey.

Use with Spatial Ability Response Sheet - one in each envelope.

NOTE 140 S's to be tested: i.e.

	Male E		Female E	
Grade	Boys	Girls	Boys	Girls
3	7	7	7	7
4	7	7	7	7
5	7	7	7	7
6	7	7	7	7
7	7	7	7	7

A. Setting Up

Greet the child. "Hello, what's your name? I'm . I'm going to ask you to help me do some puzzles. Is that O.K.? Good. Now you sit here and I'll sit next to you. (Sit next to subject on his right. Choose an envelope that has the appropriate sex of S, sex of E, and Grade marked on it.)

Fill in S's name on envelope, chart on wall and on response sheet in envelope.

B. E.F.T.

Take out the first Demonstration E.F.T. Say: "Look at this shape, (point to simple shape) I'm going to show you where it is in here, (trace in complex shape with the back of the biro). Can you do that? (Note: If child uses left hand, move to sitting on his LH). Good - now this one (take out Dem. shape 2). Here is this shape, (point to simple) in here (trace it in complex). Its turned around but its still here. Can you do it? Very good. Now you try some - remember they may be turned around, and it might occur more than once. Present the 17 shapes one at a time saying: "Now can you find this (point to simple shape) in here (point to just below complex shape). Allow 5 seconds for numbers 1 to 5

10	"	"	"	7 to 12
20	"	"	"	13 to 16
45	"	"	"	17 to 20
75	"	"	"	21 to 22

Ending E.F.T.

Say,"Good, did you enjoy that?"(See that the child has put biro down). "Can you tell me which is your right hand?"

TICK YES or NO ON RESPONSE SHEET.

C. Porteus

Say, "Now we are going to play with mazes. Do you know what a maze is? Well I'll show you the ones we're going to do". (Instructions for Porteus - These are the original and are rather complex. There are 10 mazes v,vi,vii,viii,ix,x,xi,xii,xiv and adult.)

Trials

S is allowed 2 trials for v,vi,vii, viii, ix,x,xi

4 trials for xii, xiv and adult.

Stop

If 1. S makes 2 successive failures

2. S makes 3 failures overall

3. S completes series

Inversion

To diminish the likelihood of accidental successes, the rule for inversion operates. If, after recorded failure in any test, S passes the next higher test in the allotted number of trials, this design is inverted and the test repeated as if it was a new application.

For example, if the IX year test is failed in two trials and the X year is passed, this latter must be inverted and given again. In scoring the test age, the worse of the two records, either the original or inverted, is used.

Failures and Repeats (Trials)

An unsuccessful trial is recorded as soon as S enters to any noticeable distance or degree into a blind alley. Entrance is defined as the crossing of an imaginary line across the opening leading into the blocked path or street. On no account should S be allowed to retrace his course or continue with the same design after entering a blind alley.

The only continued drawing allowed is along the path S has already entered. The design is taken from him and a new trial begun when he stops or otherwise indicates that he is blocked.

It should be noted that an unsuccessful trial does not constitute failure. If S does not succeed in the allotted number of trials - two for each test up to Year XI, four for any higher test - failure is recorded for that particular test.

Note

Neglecting to invert a test successfully passed, when failure has occurred in the test immediately below it in the series, is one of the commonest administrative mistakes made by the inexperienced examiner. The other most important error is to allow S to continue tracing through a maze design after entering a blind alley. "Wrong choice" mistakes cannot be self-corrected. Even if it is the last possible error, the test design must be withdrawn and a new trial begun. The examiner, otherwise, has no means of knowing whether a wrong choice may not be made at the same or another point in the design.

Administration

The examiner should sit opposite S and hold the Maze in position with the tips of the fingers resting on the top of the test blank. A moderately soft pencil of medium bluntness should be provided for tracing the maze. A sheet of paper should be placed under the test blank so that irregularities in the surface of the testing table will not affect performance.

Take out Maze V and say,

Examiner says: "This is what is called a maze and you must try to find your way through it. You can imagine that these lines are stone walls and that a rat came along and saw this hole". (Examiner points to entrance to the maze).

"Then he found his way between the walls until he came to the cheese. Now I want you to draw a line to show me where the rat went to get the cheese. But you must be careful not to run into any lines or go into any place that is blocked at the end. The rat cannot turn around and come back".

"And one thing more you must remember - you can stop anywhere and look as long as you want to, but try not to lift your pencil until you have found your way out. Now take this pencil and begin here (examiner points with the finger to the initial arrow) and draw for me the way the rat went to reach the cheese here." (Examiner points to exit).

Two trials are allowed.

Year VI

Examiner says: "You are to begin here (examiner points with the finger to the end of the arrow) and show me how to find your way out here." (Examiner points to exit).

Two trials allowed.

Year VII (Children's series)

Examiner says: "Begin here and find your way out here". (Examiner points to entrance and exit).

Years VIII,IX,X

Examiner says: "Begin here and find your way out." (Examiner points to the starting arrow, but not to the exit. He replies to questions as to the place of exit by telling S he must find his own way through the maze.)

Two trials allowed in each test.

Years XI,XII,XIV, and Adult I

Examiner says: "Begin here in the middle and find your way out". (Examiner points to the letter S in the centre of the test, but does not indicate point of exit.)

Two trials allowed in Year XI, four trials allowed in Years XII,XIV and Adult.

Scoring

Tick each age passed on Response sheet and enter number of trials as you go along. When S has stopped either because of 3 failures overall, 2 successive failures or has completed series

ENTER "BASIC AGE" ON RESPONSE SHEET

This is highest age passed. Adult = XV

ENTER "ADD CREDITS" ON RESPONSE SHEET

i.e. Add 1 if XII is passed or XIV is passed

Add 2 if XII is passed and XIV is passed.

ENTER "MINUS REPEATS" ON RESPONSE SHEET

i.e. add up all unsuccessful trials and divide by 2.

i.e. ½ for every unsuccessful trial.

ENTER "TEST AGE" ON RESPONSE SHEET

i.e. Basic score and add credits - minus repeat e.g. Porteus

		TEST	TRIALS	TEST	TRIALS
Basic Score	12 years	V	......	X	......
Add Credits	1	VI	......	XI	......
Minus Repeats	2½	VII	......	XIII	......
Test Age	10½	VIII	......	XIV	......
		IX	......	Adult	......

D. Directions

(Sit next to child at apparatus)

Say, "Good - did you like doing the mazes? Now lets see how good you are at knowing where you are."

CHECK that midline of apparatus is N - S, insert round sheet so that ruler line is on midline with point "1" at S.

Say, "Do you know where the front of the school is? (Take S to window and point it out, sit down next to child at apparatus). Now look at this arrow. It can move - see I am pointing it to the front of the school. (Do this, then move it through 180°). Can you point it to the front of the school? (If child is more than about 30° out, correct it for him saying, no, not quite right.) Good."

Questions 1 - 10

Do these in order. Mark response by question number only on round sheet. Allow two repeats per question if child indicates he'd like to try again. When all ten questions have been done, return to last position and say, "Good, I can see you'd never get lost."

Questions 11 - 16

Sit next to child with map facing you both. Take out map. Say, "Can you help me find my way?" DO NOT allow child to rotate map or change his position. If child cannot make a decision omit to mark response sheet for that decision. The object here is only to see if child can make the correct decision at each corner so that wording is not rigid, e.g. in number 11 say, "Yes, I walk up Lamb Road, now I have to turn, which way do I turn? Show me with your hand or the side of your body." (If child answers verbally, Right or Left, check that he really knows which side this is by saying, "Which side is that? Show me with your hand. If there is a discrepancy, score hand/side indicated not verbal response.)

Score by ticking L or R on response sheet for each decision. There are twelve decisions.

1 decision for Question 11

1 decision for Question 12

1 decision for Question 13

2 decisions for Question 14

3 decisions for Question 15

4 decisions for Question 16

Questions 17 - 24

If child is accompanied by other child/children, score this as adult if companion is over 13. Simply tick yes or no on response sheet.

Questions 25, 26,

Write answers on dotted line.

QUESTIONS.

1. Please could you point the arrow to the park opposite the school?
2. Please could you point the arrow to North?
3. Please could you point the arrow to the Zoo?
4. Please could you point the arrow to East?
5. Please could you point the arrow to the Castle?
6. Please could you point the arrow to South?
7. Please could you point the arrow to Glasgow?
8. Please could you point the arrow to West?
9. Please could you point the arrow to Maybury Traffic Circle/showground, Royal Scot Hotel?
10. Please could you point the arrow to South West?
11. How do I get from the trees on Lamb Road to the letter box on the traffic circle?
12. How do I get from the bicycle on Cat Road to the ice cream van on the traffic circle?
13. How do I get from the car on Rabbit Road to the letter box on the traffic circle?
14. How do I get from the shop on Dog Road to the car on Rabbit Road?
15. How do I get from the house on Boy Road to the ice cream van on the traffic circle?
16. How do I get from the car on Rabbit Road to the house on Boy Road?
17. Are you allowed out of your garden without a big person (adult)?
18. Are you allowed to cross the road without a big person (adult) or a lolly man?
19. Do you come ot school without a big person (adult)?
20. Are you allowed to go to the shops without a big person (adult)?
21. Do you ride a bicycle?

22. If you do ride a bicycle are you allowed to ride it in the street you live in?

23. If you do ride a bicycle are you allowed to ride it further than the street you live in?

24. Are you allowed to catch a bus without a big person (adult)?

25. What do you want to do after you leave school?

26. Why do you want to do that?

E. WISC

Say, "Now we are going to do some coding like spies use (break here and talk to child about spies, etc. to break up test session.) Well, I see you know all about spies, so let's see how you can code."

DIRECTIONS

Say, "Look at these divided boxes or squares pointing to the Key. Notice that each has a number on the upper part and a mark on the lower part. Every number has a different mark. Now look here (pointing to the Sample) where the boxes have numbers, but the squares beneath have no marks. I want you to put in each of these squares (pointing to the seven Sample boxes) the marks that should go there like this."

Illustrate by pointing to the Key and then to the Sample, saying, "Here is a 2, so put in this mark (writing in the symbol). Here is a 1, so you put in this mark. This is a 4, so you put in this mark." After marking the first three Sample items, say, "Now you do it". (If the Subject does not grasp the task, help him with more items until the seven Sample items have been filled in.)

After this demonstration, say, "Now begin here and fill in as many squares as you can without missing any out. Keep working until I tell you to stop. Go ahead." (Begin timing. If the Subject starts to omit squares or do only one type of figure, say, "Do them in order.")

Timing 120 seconds.

Scoring DO NOT SCORE

CHECK AGE - IF OVER 8, SKIP TO * PAGE

Similarities

Say, "Now I'd like you to answer some questions!"

Analogies

DIRECTIONS

Before reading each item, say, "Finish what I want to say." All four items are given to the Subject.

1. Lemons are sour but sugar is ______________

2. You walk with your legs and throw with your ______________

3. Boys grow up to be men and girls to be ______________

4. A knife and a piece of glass both ______________

If the Subject fails to complete the first sentence, or seems not to understand, finish it for him, thus: Lemons are sour but sugar is sweet. The same procedure is followed if the Subject fails the second sentence. After this no further help is given. If the Subject succeeds, say, "That is right, now try this one", and continue with the remaining sentences.

If the Subject passes two of the four items, proceed with Similarities.

SCORING

One point for each item correctly answered. The only correct responses for the items are, respectively: 1.sweet; 2.arms,hands; 3.women, ladies, mothers; 4.cut.

*SIMILARITIES

For Subjects 8 and older

DIRECTIONS Say, "In what way are an APPLE and an ORANGE alike?"

If the Subject says that they are not alike, fails to answer, or gives an inferior reply, say, "Oh yes, they are both fruit, you eat both

both, and both have skins and seeds. Now tell me in what way are a CAT and a MOUSE alike?"

If the Subject fails on CAT-MOUSE, explain again and go on to item 7, but give no further help.

Subjects who have not been given Analogies and who score less than three points on Similarities must be given Analogies according to the instructions for younger children. They are given the total of points earned on both parts of the test.

Subjects who begin with Similarities and earn at least three points are given full credit (four points) for Analogies.

DISCONTINUE

Three consecutive failures (responses scored 0) on the Similarities items.

SCORING Write in responses on response sheet - do not score.

Picture Arrangement

See WISC, Pages 23 - 25

SCORING Enter order and time on response sheet. Do not score

F. LATERALITY

Is S Right or Left handed?

TICK L or R on RESPONSE SHEET

Ask " which is your right hand?" (I know this has been asked before. Is S able to identify RH?)

TICK YES or NO on RESPONSE SHEET

ENTER YOUR NUMBER ON RESPONSE SHEET

G. KEOGH SHAPES

Say, "Now just to end up, lets do some drawing. Lets see how well you can copy shapes (hold up DEM card) Can you copy this exactly the same (Give child practice sheet). Good."

Now present designs to 1-9 with appropriate sheets. Do not allow rubbing out or redrawing. Model must be visible at all times. No time limit.

File 9 completed drawings in envelope.

MEANINGFUL KEOGH

Say "Now we are going to copy some things. Please copy them exactly the same.

1. This is a candle. Please copy it exactly the same.
2. This is an egg. Please copy it exactly the same.
3. This is a hat. Please copy it exactly the same.
4. This is a flag. Please copy it exactly the same.
5. This is a pair of spectacles. Please copy it exactly the same.
6. This is a house. Please copy it exactly the same.
7. This is a kite. Please copy it exactly the same.
8. This is an umbrella. Please copy it exactly the same.
9. This is a worm. Please copy it exactly the same.

Thank you very much.

File 9 drawings in envelope.

Make sure:

1. You have entered S's name three times.
2. You have placed response sheet in envelope.
3. You have placed nine Keogh drawings in envelope.
4. You have placed nine meaningful Keogh drawings in envelope.
5. You have placed round sheet in envelope.

Instructions for Keogh Drawing

Each experimenter to test one boy and then one girl while the other acts as photographer. Then swop roles. Each experimenter is to test altogether 7 boys and 7 girls from Grade 4.

Choosing Children

Choose a child from the chart so that you ensure that that child is being tested by the SAME SEX EXPERIMENTER as is due to, or has, tested him/her at school.

Absentees

If a child is absent, check if their name is ticked on the chart. This indicates (if ticked) that they have already been tested at school.
IF TICKED Do not replace - we will have to chase up the child.
IF NOT TICKED Replace with "reserve" of same sex, same form. Then cross out original child's name on chart and insert replacement's name.

Film

Each child walks through 18 shapes and 1 demonstration. (Do not photograph demonstration). This gives 2 children for each spool as spool holds 36 shots. Thus camera can be reloaded as Experimenters swop roles.

Instructions

Make sure you have child's number ready. Say 'Hello, we are going to copy some shapes in a new kind of way. Look, you put these socks on (help child with socks). Right, now stand in here (place child with feet in bucket so that socks get saturated with dust). See, (lead child up edge of board) you can make a line. Now, can you copy this? (Hold up Dem.K shape and direct child to make this pattern using about

3/4 of area). Good, (clean board).

Then hold up K1 and say, "Now can you copy this shape exactly the same?" When the child has finished, write his/her number in middle and also Keogh number e.g. 1131 K1.

The other experimenter then takes a shot* Clean board. Repeat for K2 - K9.

Then say, "Now we are going to copy some things. Please copy them exactly the same".

Hold up MK1 and say, "This is a candle, please copy it exactly the same." Insert number e.g. 1131 MK1, photograph and clean board.

1. "This is an egg, please copy it exactly the same". Insert number, photograph and clean board.
2. "This is a hat, please copy it exactly the same". Insert number, photograph and clean board.
3. "This is a flag, please copy it exactly the same." Insert number, photograph and clean board.
4. "This is a pair of spectacles, please copy it exactly the same". Insert number, photograph and clean board.
5. "This is a house, please copy it exactly the same". Insert number, photograph and clean board.
6. "This is a kite, please copy it exactly the same." Insert number, Photograph and clean board.
7. "This is an umbrella, please copy it exactly the same". Insert number, photograph and clean board.
8. "This is a worm, please copy it exactly the same". Insert number, photograph and clean board.

"Thank you very much".

*

Ensure: 1. That you have changed roles every second child.
2. That you have loaded camera every second child.
3. That you are conforming to chart with respect to sex of Experimenter and sex of child.

Instructions for Stage 2.

Forms 2 and 4 only

Instructions for coaching and practice groups first administration.

Give each child a booklet face downwards and a pencil and a rubber. Then page overleaf, as far as *. Then, "Has everyone got a booklet, pencil and rubber? Please fill in your Christian and surname and tutor group and then put your pencil down. Please don't open the booklet until I tell you to do so. Now, this experiment is concerned with spatial ability, that is , how well you can work with shapes. Please remember, it isn't a test of you individually at all, but that we are concerned with the group as a whole. Do your best, but don't worry. If you break the point of your pencil, put your hand up and we'll give you another one.

Any questions?

Ready? Once again, don't worry if you can't do all the items and remember we are interested in the group as a whole, your performance won't affect you in any way at all."

Follow instructions on page overleaf at * until *

Spatial Ability Survey Craigmount School

Instructions to Experimenter.

Introduction

"Good morning (afternoon). My name is Gerda Siann, and this is Andrew Millar. We're from the University of Edinburgh and we're here to ask you to help us in an experiment. Do you know what an experiment is?"

(Form 1: remind of earlier experiment at Corstorphine)

Pause for short discussion on this.

"Good. Well then you'll be aware of how careful we have to be not to bias the results in any way. That's why I'm going to ask you not to talk at all during the experiment, or to try and see what your neighbour is doing.

I'm sure you're wondering what the experiment is about. Well it's concerned with the differences between two groups when they are doing certain tasks. The two groups are boys and girls. Some people believe that one group is better than the other at the kind of tasks we're going to ask you to do today. I'm not going to tell you whether its boys or girls that are thought of as better. Can you guess why not?"

Discuss expectation effects.*

"Now, as you'll see, the experiment is divided into two and we're about to start the first. This will last about 15 minutes and then we'll have a break. Please remember that these tasks are <u>not a test</u> of you individually at all, but are concerned with the group as a whole. Do your best, but don't worry.

Any questions?

Please don't touch the booklet till I tell you."

Each child to be given 2 booklets, a pencil and a rubber, Booklet 1 on top.

"Has everyone got a pencil and rubber? Good. Now we are going to fill in the first page of booklet 1. Has everyone got a booklet saying "Survey of Spatial Ability"?" (Check each child has right booklet on top). "Now let's fill in the first sheet but don't turn over until you are told"

BASIC DATA

"If you break the point of your pencil, put your hand up and we'll give you another." (Go through name, sex, Tutor group, date of birth.)
"Please don't say 'don't know' to the next 2 questions. I'm sure you have some idea of your future plans." (Wait for 3 - 5 minutes)
Research assistant to check this is done correctly.
"Has everyone finished? Good. Now we're going to start Section 1. Please turn over."

A.H.4

(Read over instructions at top of page. Make sure everyone realises that they have either to fill in a number or tick a word for each question.)
"Now try the examples".

1. "Take your time and when you've finished the examples will you put down your pencils so that I can see when you are ready."
   Give help with examples as described on p.2. Make sure that quicker subjects do not turn over to the test proper. When everybody has correctly completed the examples:
2. "Correct answers to the examples you've been doing are as follows (read slowly) 9. small, 16.good, 4. present.
3. All ready now?...Any questions?...The examples are to give you an idea of what the test is like.
4. Work through the questions in order. Don't leave any out unless you're really stumped.
5. If your pencil breaks, let me know and I'll give you another one.
   If you make a mistake, just rub it out and correct it.

6. The experiment is in 5 sections. The first section has five pages and lasts ten minutes.

7. If you're not clear about anything, ask me NOW. There can be no questions once the test has started."

   Encourage questions, if necessary, as complete silence is essential during test period.

8. "All ready?...Then turn over to p.4 (pause), and BEGIN. (Start stopwatch and demonstrate its use)

   After a pause go round to see that subjects are happily started and that they are entering their answers correctly. Make further unobtrusive rounds of inspection every 3 or 4 minutes. Be sure that subjects do not mark question books, and do not copy from their neighbours.

   When the fastest subjects are reading the bottom of p.5:

9. "If you finish one page, go straight on to the next."

   It is important to ensure that , in both parts, all subjects turn over as soon as they have finished a page, and that they consistently use the appropriate space on the answer sheet.

   At the end of 10 minutes:

10. "Right, that's the end of the first part. Don't worry if you haven't finished - people very rarely do."

MOTIVATION A.H.4

"Now will you tell us how much you liked doing this section by filling in the question at the bottom of page 9. Don't turn over till I tell you and please put your pencils down after you've answered the question."
(Check everyone has answered questions and put their pencils down.)

MAP READING

"Now we are going to do a map reading task. Please turn over and look at the map on your left. Can you see the school? Put a finger on it. Can you see the park? Put a finger on the park. We are going to imagine we are walking from the school to the park following the route indicated by the dotted line. Can you see the dotted line? Notice there are 15 turns on this route, numbered 1 to 15. Right, please take your hands off the map and from now on don't touch the map, or turn the booklet. Please put your pencils down if you're holding them. Look at the opposite page. This is where you will write the answers. Notice that there are 15 numbers down the left hand side of the paper matching the 15 turns. Let's try and do the answer to the first turn - walking from the school to the park, when we reach turn 1 we will have to turn left, wouldn't we? That's why on the answer page, next to number 1, we have ticked the left hand column. Now imagine you are walking further along the route, and reach the turn at 2. Which way would we turn? Right? Yes, that's correct. Pick up your pencils and next to number 2 tick the right hand column. Now put your pencils down."

Research assistant to check everyone has done this correctly.

"When I say start, I want you to pick up your pencils and fill in the answers 3 to 15. You will have 1½ minutes. Please don't turn the booklet or touch the map or mark the map page in any way. Any questions? START".

(Time - 1½ minutes)

"Good - now just some questions about your interests. Please turn over the page.

INTERESTS

(Read the questions out aloud and assistant to check that children fill in all answers).

"Good. That's the end of Part 1 - you will have a 5 minute break. Please don't look at the second booklet."

SPACE TEST

"Ready? Well put your pencils down and look up. This part is concerned with how well you can work with shapes. Once again don't worry if you can't do any of them. Remember, we are interested in the group as a whole - your performance won't affect you in any way at all. Please write your name in." (Read out instructions on page 1 of Booklet 2)*

Section 1 (Time allowed: 7 minutes)

As soon as the rules are read, the supervisor says: "When I say 'Turn over', you are to turn over, read for yourself the instructions on page 2, and begin work on page 3. Go on to the bottom of page 4. Do not turn over page until you are told. You have 7 minutes to do the questions on pages 3 and 4. Remember to work as quickly and as carefully as you can. Are you ready? Turn over, begin now."

After 7 minutes, the supervisor says, "Stop working, pencils down."

Section 2 (Time allowed: 10 minutes)

After a short pause, the supervisor says, "When I say 'Turn over'. you are to turn over, read for yourself the instructions on page 6, and then begin work on page 7. Go on to the bottom of page 7. Do not turn over to page 8 until you are told. You have 10 minutes to do the questions on page 7. It will help if you fill in the dotted line as in the example. Are you ready? Turn over, begin now."

After 10 minutes he says, "Stop working, pencils down."

Section 3 (Time allowed: 4 minutes)

After a short pause, the supervisor says, "When I say 'Turn over' you are to turn over, read for yourself the instructions on page 8, and then begin work on page 9. Go on to the bottom of page 9. Do not turn over to page 10 until you are told. You have 4 minutes to do the questions on page 9. Are you ready? Turn over, begin now."

After 4 minutes he says, "Stop working, pencils down."

Section 4 (Time allowed: 6 minutes)

After a short pause, the supervisor says, "When I say 'Turn over', you are to turn over, read for yourself the instructions on page 10, and then begin work on page 11. Go on to the bottom of page 11. Do not turn over to page 12 until you are told. You have 6 minutes to do the questions on page 11. Are you ready? Turn over, begin now."

After 6 minutes he says, "Stop working, pencils down."

Section 5 (Time allowed: 4 minutes)

After a short pause, the supervisor says, "When I say 'Turn over', you are to turn over, read for yourself the instructions on page 12, and then begin work on page 13. Go on to the bottom of page 13. You have 4 minutes to do the questions on page 13. Are you ready? Turn over, begin now." The supervisor writes down the exact time when he says, "Begin now", and also what the time will be 4 minutes later. After 4 minutes he says, "Stop working, pencils down."*

MOTIVATION 2

"Right, will everyone tell me how much they enjoyed this part of the experiment." (Check each child fills in question 64)

DIRECTIONS Experimenter and assistant check that all desks are parallel to walls.

"Now we are going to do the very last part of the experiment. This part is concerned with your sense of direction. Put your pencils down. Turn your booklet over. Place it so the line on the bottom of the page is along the edge of your desk facing you." (Check that all children have done this) .

"Now, just to give you a reference point, the round block, in the car park (where the Head's office is) is in that direction __2__

(Point to appropriate direction)

From where you're sitting __2__ is the line pointing in this direction. Pick up your pencils and fill in the other answers."

(Time 1 minute)

"Good, thank you very much."

(Collect booklets, and ensure code numbers are the same.)

APPENDIX V.

Rules to help in answering Spatial Problems in Booklet 2.

In all questions fix the shape firmly in your mind by:

1. Pretending it's a real object (a foot, a gun, a house).
2. Describing it in words to yourself (a house with a tall chimney at one end and a small chimney at the other end).

Section 1.

a) Find a 'special' point and describe it (the 'toe' of the foot, the only square corner).

b) Going clockwise, what is the next bit you come to? (the heel, the sharp corner).

c) Now find the only shape which has the same order if you go clockwise.

Section 2.

There are three shapes - the middle piece is short, medium or long - and each can be one way round or the other.

To find how to divide the shape in two:

a) Look for the stepped edges - your line must go between them.

b) Look for any strange hole in the shape - your line must go through it.

c) Put your pencil, rubber, fingers on the paper to cover one piece to check.

d) When you've found the shapes, use the 'clockwise' method to check which shapes they are.

Section 3.

This is similar to Section 1.

a) Imagine yourself sitting at the 'special point' of the 'house' or or 'factory'.

b) What will you see on your left, right, in front of you? (Describe these views to yourself in words.)

c) When a shape seems right, check these descriptions with the one on the left.

Section 4.

a) Describe the shape in words (a flat block with a small block sticking up in the middle.)

b) Now look for a shape with a hole in every place the other had a block (a flat block with a small hole in the middle.)

c) Remember to count - the two pieces together must add up to 12 small square blocks, so if the question has 7, the answer must have 5.

Section 5.

a) If the block with the letter is on the outside:
Imagine yourself actually removing the block from a wooden puzzle.

b) If the block with the letter is in the inside:
Imagine yourself actually removing blocks from on top of it (or from below it) until you uncover it, and then removing it.

REMEMBER: In all sections, talk to yourself, describe the problem in words, try to imagine it as a real, solid object, made of wood or metal or bricks, or skin and bones.

APPENDIX VI

BOOKLETS FOR PROJECT 2

(pages 450 - 475)

SURVEY OF SPATIAL ABILITY

PUPIL DO NOT FILL THIS IN

1			
1	2	3	4

NAME

Sex Male ◯ 1 Female ◯ 2 (please tick circle)

5

Tutor Group

6

Date of Birth

7 8 9 10

Please can you answer these questions?

What do you plan to do when you leave school?
(Please answer as fully as possible mentioning, if it is applicable, any further study you would have to undertake in order to do the particular job you are interested in. If you have more than one career in mind please list all the possible alternatives you are interested in.)

11 12 13 14 15 16

What do you think you will be doing when you are 30 years old?

17 18 19 20

PLEASE DON'T TURN OVER UNTIL YOU ARE TOLD.

PART 1.

Part 1 is concerned with the ability to think logically about the kinds of problems you might sometimes come across in your school work. Here are some examples to practice on. Some of the examples are already done for you.

EXAMPLES

1. 1, 2, 3, 4, 5, 6, 7, 8, 9. Write down the largest of these figures.

answer [ ]

2. 1, 2, 3, 4, 5, 6, 7, 8, 9. Write down the middle on of these figures.

answer [5]

3. Late means the opposite of ... (1) appointment, (2) early, (3) behind, (4) postponed, (5) immediate.

4. Big means the opposite of ... (1) tall, (2) large, (3) place, (4) small, (5) high. (tick the answer)

5. 1, 4, 7, 10, 13, What number comes next?

answer [|]

6. 2, 4, 8, 16, 32, What number comes next?

answer [6 | 4]

7. Fish is to swim as bird is to ... (1) man, (2) fly, (3) walk, (4) aeroplane, (5) sparrow.

8. Low is to high as bad is to ... (1) evil, (2) red, (3) try, (4) good, (5) right.

9. There are 3 figures: 325. Add the largest two figures together and divide the total by the smallest figure.

answer [ ]

10. There are 3 figures: 594. Subtract the smallest figure from the biggest and multiply the result by the figure printed immediately before the biggest figure.

answer [2 | 5]

11. Young means the same as ... (1) youthful, (2) ancient, (3) vigorous, (4) hot, (5) baby.

12. Gift means the same as ... (1) parcel, (2) toy, (3) birthday, (4) buy, (5) present.

If there is anything you do not understand, please ask the tester now.

DO NOT TURN OVER UNTIL YOU ARE TOLD TO DO SO.

DO NOT TURN OVER
UNTIL YOU ARE TOLD

NOT TO BE FILLED IN BY PUPIL

<u>Note.</u> When the answer is a number, please write it in the box or boxes.

When the answer is a word, please tick the word you think is correct.

1, 2, 3, 4, 5, 6, 7, 8, 9. Multiply the middle one of these figures by 2. 21-22

answer

1 2
<u>Easy</u> means the opposite of ... problem, simple, 23
3 4 5
difficult, always, cannot.

15, 35, 55, 75, 95 ... What number comes next 24-26

answer

1 2
<u>Seed</u> is to <u>plant</u> as <u>egg</u> is to ... tree, bird, 27
3 4 5
pollen, oats, potato.

Here are three figures: 234. Divide the biggest figure by the smallest and add the result to the figure printed immediately after the smallest figure. 28

answer

1 2 3
<u>Rich</u> means the same as ... poor, wealthy, high, 29
4 5
new, lucky.

1, 2, 3, 4, 5, 6, 7, 8, 9. Write down the fourth figure to the left of 7. 30

answer

1 2
<u>Right</u> means the opposite of ... action, good 31
3 4 5
careless, wrong, motive.

1, 2, 4, 8, 16... What number comes next? 32-33

answer

1 2
<u>Foot</u> is to <u>leg</u> as <u>hand</u> is to ...body, finger, 34
3 4 5
tall, limb, arm.

Here are three figures: 327. Subtract the smallest figure from the biggest and multiply the result by the figure printed immediately before the biggest figure. 35-36

answer

1 2
<u>Old</u> means the same as ... decaying, tired, 37
3 4 5
aged, youth, mended.

GO ON TO NEXT PAGE

NOT TO BE FILLED IN BY PUPIL

1, 2, 3, 4, 5, 6, 7, 8, 9. Add the first five figures together and subtract them from the sum of the last four | 38-39

answer [|]

<u>Lost</u> means the opposite of ... winning (1), draw (2), found (3), alone (4), mislaid (5). | 40

3,3,7, 7,11 ... What number comes next? | 41-42

answer [|]

<u>Army</u> is to <u>navy</u> as <u>soldier</u> is to ... airman (1), sea (2), service (3), sailor (4), uniform (5). | 43

Here are three figures: 132. Divide the biggest figure by the smallest and add the result to the figure printed immediately after the smallest figure. | 44

answer [ ]

<u>Portion</u> means the same as ... some (1), whole (2), part (3), any (4), cake (5). | 45

If a castle is bigger than a cottage, write down the second of these figures: 1, 2, 3, 4, 5, 6, 7, 8, 9. If it is not, write down the sixth. | 46

answer [ ]

<u>Up</u> means the opposite of ... short (1), small (2), low (3), down (4), young (5). | 47

1000, 100, 10 ... What number comes next. | 48

answer [ ]

Seeing is to picture as hearing is to ... sight (1), sculpture (2), ear (3), song (4), deaf (5). | 49

Here are three figures: 189. Subtract the smallest figure from the biggest and multiply the result by the figure printed immediately before the biggest figure. | 50-51

answer [|]

GO ON TO NEXT PAGE

NOT TO BE
FILLED IN
BY PUPIL

1 2
Ill means the same as ... health, fever, 52
3 4 5
dirty, mumps, sick.

Write down the number of letters in the fourth 53
word of this sentence. answer

1 2
Near means the opposite of ... close, road, 54
3 4 5
speed, far, distance.

2, 3, 5, 8, 12 ... What number comes next? answer 55-56

Legs are to running as teeth are to ... 57
1 2 3 4 5
chattering, walking, eating, biting, arms.

Here are three figures: 682. Add the largest 58
two figures together and divide the total by
the smallest figure. answer

1
Scarce means the same as ... unobtainable, 59
2 3 4 5
lack, unique, rare, frightened.

If Z is the last letter of the alphabet and 60
if B does not come before A, write down the
fifth of these figures:
1, 2, 3, 4, 5, 6, 7, 8, 9. Otherwise, write
down the last one. answer

1 2
Never means the opposite of ... rarely, always 61
3 4 5
now, will, forget.

1, 2, 4, 5, 7 ... What number comes next? answer 62

1
Sky is to ground as ceiling is to ... roof, 63
2 3 4 5
down, floor, rug, high.

Here are three figures: 823. Divide the 64
biggest figure by the smallest and add the
result to the figure printed immediately
after the smallest figure. answer

GO ON TO NEXT PAGE

NOT TO BE FILLED IN BY PUPIL

1 2
Odd means the same as ... strange, even, 65
3 4 5
one, man, number.

If 8 is more than 3, write down 7, unless 3 is more than 7, in which case write 8. 66

answer

1
War means the opposite of ... suffering, 67
2 3 4 5
joy, dictatorship, inflation, peace.

11, 12, 10, 13, 9 ... What number comes next? 68-69

answer

1 2
When is to where as time is to ... how, why, 70
3 4 5
space, length, relativity.

Here is a row of figures: 1, 2, 3, 4, 5, 6, 7, 8, 9. Write down the figure from this row which, when added to another number smaller than it, would make 17. 71

answer

1
Backwards means the same as ... upside-down, 72
2 3 4 5
reversed, stop, forwards, gear.

If 20 is more than 3 times 5, write down the figure 2, unless 14 is less than 16, in which case write 7. 73

answer

1
Multiplication is the opposite of ... subtraction, 74
2 3 4 5
addition, mathematics, figures, division.

0.9, 1.1, 1.3, 1.5, 1.7 ... What number comes next? 75-76

answer

1
Autumn is to Winter as October is to ... April 77
2 3 4 5
July, Spring, rain, January.

GO ON TO NEXT PAGE

NOT TO BE
FILLED IN
BY PUPIL

Here are three figures: 456. Subtract the smallest figure from the biggest and multiply the result by the figure printed immediately before the biggest figure. 78-79

answer

2nd card 2 1- 5

Prevent means the same as ... 6
1 2 3 4 5
avoid, cure, allow, deter, help.

Write down the total number of letters contained in the words in this sentence. 7-8

answer

1
Permanent means the opposite of ... part-time, 9
2 3 4 5
ever, changing, temporary, stable.

100, 81, 64, 49, 36 ... What number comes next? 10-11

answer

Fact is to fiction as historian 12
1 2 3 4
is to ... history, book, novelist, teacher,
5
story.

Here are three figures: 934. Divide the biggest figure by the smallest and add the result to the figure printed immediately after the smallest figure. 13

answer

1
Industrious means the same as ... busy, 14
2 3 4 5
hard-working, energetic, over-worked, happy

If G is the seventh letter of the alphabet and Wednesday is not a month of the year, divide 63 by 7. Otherwise subtract 3 from 5. Write down your answer. 15

answer

1
Dangerous means the opposite of ... brave, 16
2 3 4 5
cowardly, situation, safe, bravado.

GO ON TO NEXT PAGE

NOT TO BE FILLED IN BY PUPIL

0.1, 1.3, 2.5, 3.7, 4.9... What number comes next? answer $\square \cdot \square$ | 17-18

Motive is to method as why is to ... | 19

wherefore (1), reason (2), how (3), because (4), where (5).

Here are three figures: 847. Divide the biggest figure by the smallest and add the result to the figure printed immediately after the smallest figure. answer $\square$ | 20

Flat means the same as ... straight (1), level (2), uneven (3), oblique (4), inclined (5). | 21

0, 2, 8, 26, 80 ... What number comes next? answer $\square\square\square$ | 22-24

Doubt means the opposite of ... wonder (1), certainty (2), correct (3), dubious (4), indefinite (5). | 25

130, 118, 107, 97, 88 ... What number comes next? answer $\square\square$ | 26-27

The day after tomorrow is to the day before yesterday as Wednesday is to Friday (1), Saturday (2), Sunday (3), Monday (4), Tuesday (5). | 28

Here are three figures: 948. Divide the biggest figure by the smallest and add the result to $1\frac{3}{4}$. answer $\square$ | 29

END OF PART I

How much have you enjoyed doing this section? (Please tick the appropriate box).

a lot (1) $\square$ a little (2) $\square$ not very much (3) $\square$ not at all (4) $\square$ | 30

couldn't say (5) $\square$

DO NOT TURN OVER UNTIL YOU ARE TOLD.


School
A
Park
B
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

SECTION 2

MAP READING TEST

Imagine you are going from your school at point A to the park at point B. The path that you will follow is mapped out for you. As you see there are 15 decisions to be made. The first (1) is to take the turn on the LEFT. Now fill out the other 14 decisions by ticking the appropriate box.

Decision Point	Left	Right	Do not write in this column Punching Left = 1 Right = 2
1.	✓		31
2.			32
3.			33
4.			34
5.			35
6.			36
7.			37
8.			38
9.			39
10.			40
11.			41
12.			42
13.			43
14.			44
15.			45

DO NOT TURN OVER UNTIL YOU ARE TOLD

SECTION 3

INTEREST QUESTIONNAIRE

NOT TO BE FILLED IN BY PUPIL

How often do you do the following:-

	1 Very Often	2 Quite Often	3 Occasionally	4 Never	
Ride a bike					46
Go Orienteering					47
Play Chess					48
Do Woodwork and/or make Models (Outside school hours)					49
Draw or paint (outside school hours)					50
Make your own clothes (outside school hours)					51
Make up your own patterns for sewing clothes (outside school hours)					52
Knit or crochet using a pattern (outside school hours)					53
Knit or crochet without using pattern (outside school hours)					54

When you were younger did you play with Leggo, Meccano or similar toys

1 ☐ a lot   2 ☐ a little   3 ☐ never   4 ☐ can't remember   55

Have you every had woodwork classes at school?   1 ☐ Yes   2 ☐ No   56

Have you ever had technical drawing classes at school?   1 ☐ Yes   2 ☐ No   57

NAME

Card 3 | 3 | | | | 1-4

BOOKLET 2 PART 4

This part is concerned with spatial ability. Here are the instructions for it:

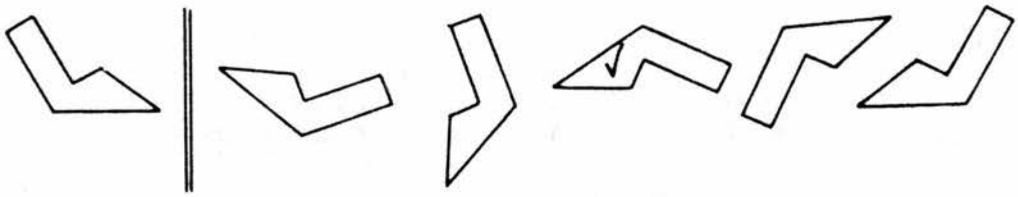
1. When you are told to begin, turn over to page 2 and start working at once. At the end of each page, follow the instructions given at the bottom.
2. The test is in 5 sections. You will be told how much time is allowed for each section.
3. Each time you are told to stop, STOP WORKING AT ONCE.
4. Work as quickly and as carefully as you can.
5. If you try a question and find you can't answer it leave it and go on to the next.
6. Make any changes in your answers clearly

SPATIAL TEST

SECTION 1

Look at the row of drawings below (Example 1).

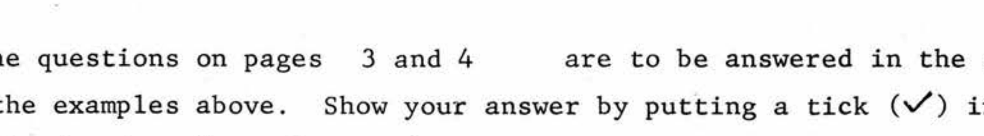
Example 1.



In this row we have to find among the five drawings on the right of the double line ONE which is the same as that on the left of the line after it has been TURNED ROUND on the page. The correct answer is the third drawing, so we have put a tick (✓) inside this drawing. The other four drawings are wrong as they only match the drawing on the left after it has been turned over as well as turned round.

Now look at Example 2 below. As before, one of the drawings on the right of the double line is the same as the drawing on the left of the line after it has been TURNED ROUND on the page. The correct answer is the first drawing, so we have put a tick (✓) inside this drawing. See why the other four drawings are wrong.

Example 2.



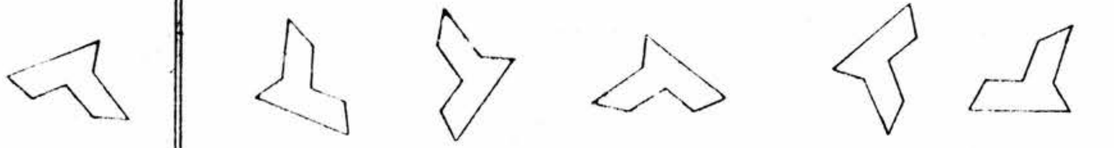
The questions on pages 3 and 4 are to be answered in the same way as the examples above. Show your answer by putting a tick (✓) inside ONE of the drawings in each question.

GO STRAIGHT ON TO PAGE 3 AND BEGIN AT ONCE

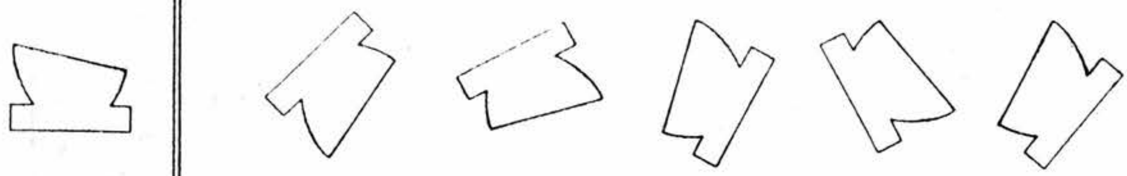
SECTION 1

Do not write in this column.

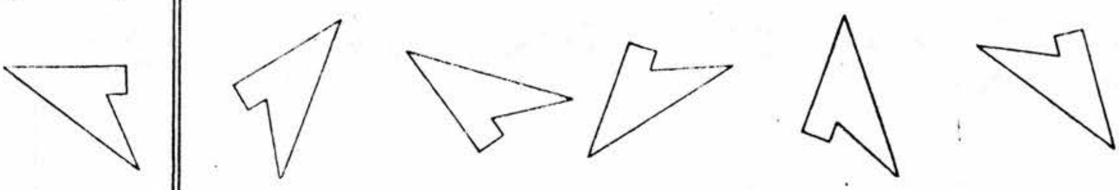
1 2 3 4 5



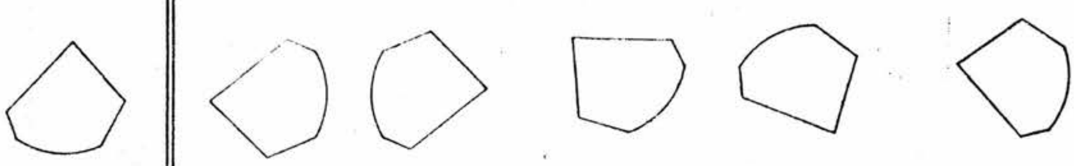
5



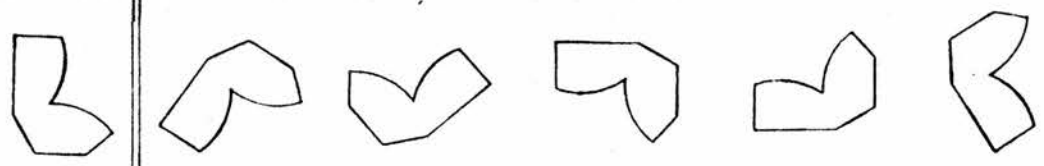
6



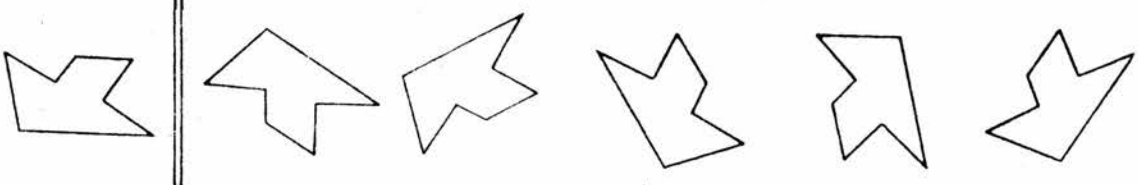
7



8



9



10

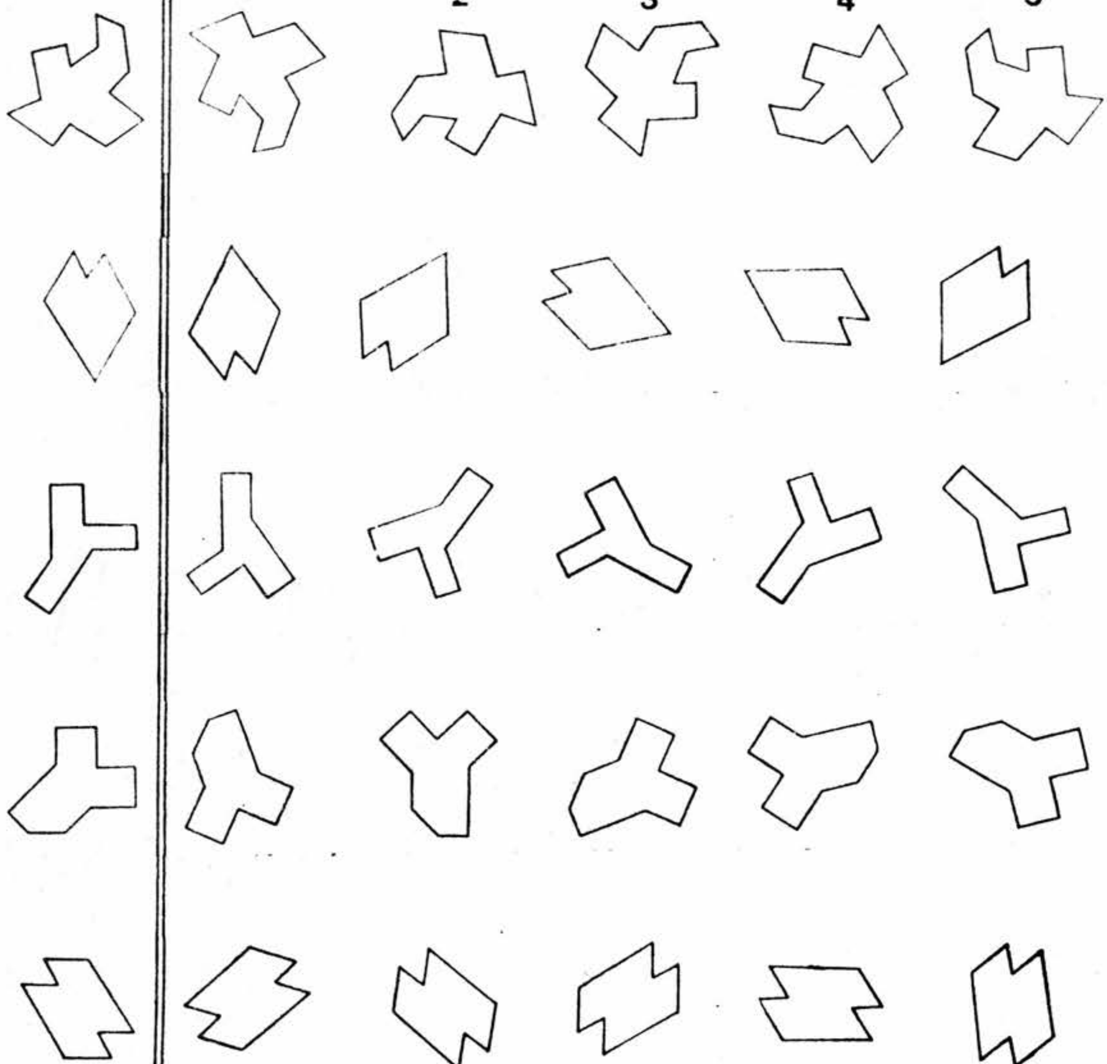
11

GO STRAIGHT ON TO PAGE 4

Do not wr
In this colu

SECTION 1

1 2 3 4 5



12

13

14

15

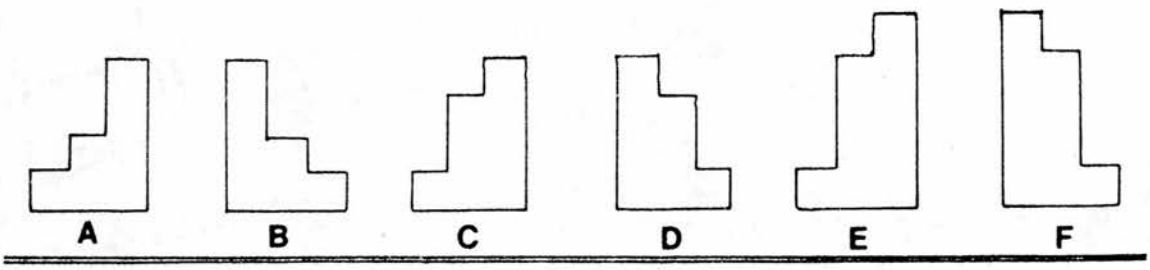
16

LOOK OVER YOUR WORK IN THIS SECTION ONLY TILL TIME IS UP

DO NOT TURN OVER UNTIL YOU ARE TOLD

DO NOT TURN OVER
UNTIL YOU ARE TOLD

SECTION 2



In the row above are six different shapes, lettered A, B, C, D, E, F.

In the examples below are three drawings: each has been made by fitting together <u>two different</u> shapes from the row above.

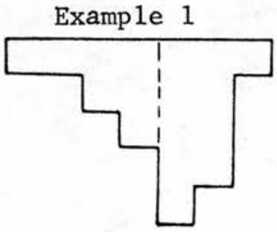
You have to find out in each case which <u>two different</u> shapes have been fitted together, and write the letters of these two shapes on the line below the drawing.

The shapes may be turned round on the page but <u>not</u> turned over: note that in each pair of shapes A B, C D, E F, one is the <u>reverse</u> of the other.

Look at Example 1. The only two shapes in the above row which can be fitted together to make the drawing are A and E, so we have written A E under the drawing.

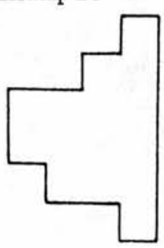
Examples 2 and 3 have been done in the same way and the answers are given. See how they have been obtained. The order of the letters in the answer does not matter.

Example 1



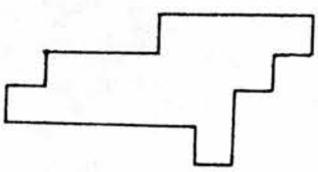
| A | E |

Example 2



| B | C |

Example 3



| F | A |

The questions on page **7** are to be answered in the same way. Write TWO letters for each answer.

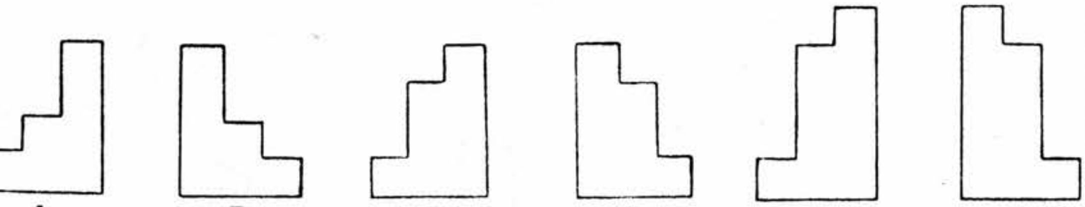
GO STRAIGHT ON TO PAGE 7 AND BEGIN AT ONCE

SECTION 2

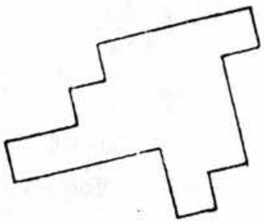
Do not write in this column.

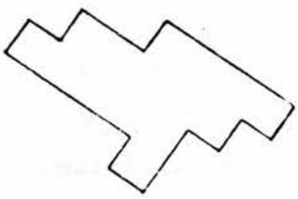
Punching

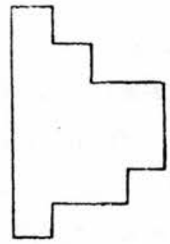
A - 1
B - 2
C - 3
D - 4
E - 5
F - 6



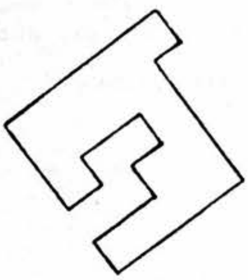
A B C D E F

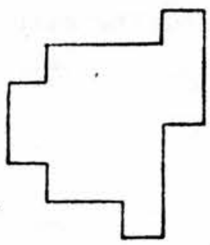


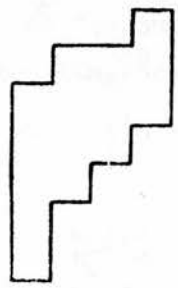




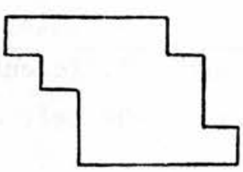
17/18 19/20 21/22

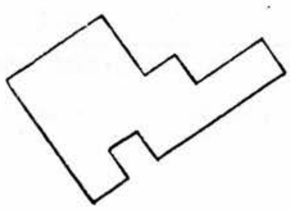


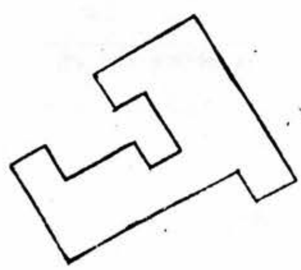




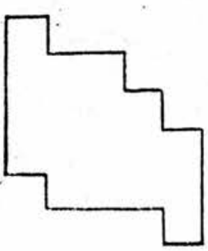
23/24 25/26 27/28

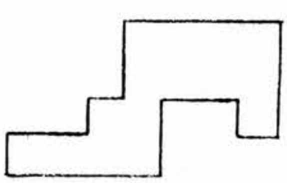


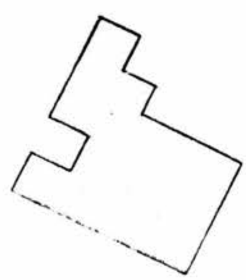




29/30 31/32 33/34







35/36 37/38 39/40

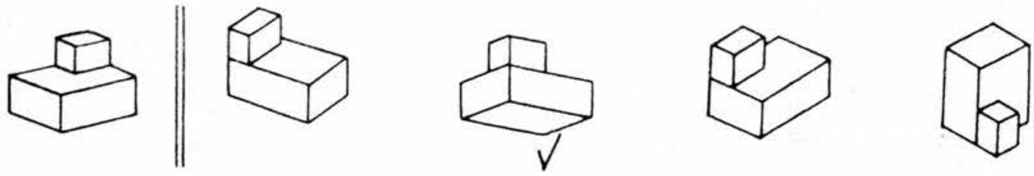
LOOK OVER YOUR WORK IN THIS SECTION ONLY TILL TIME IS UP

DO NOT TURN OVER UNTIL YOU ARE TOLD

SECTION 3

Look at the row of drawings below (Example 1).

Example 1.

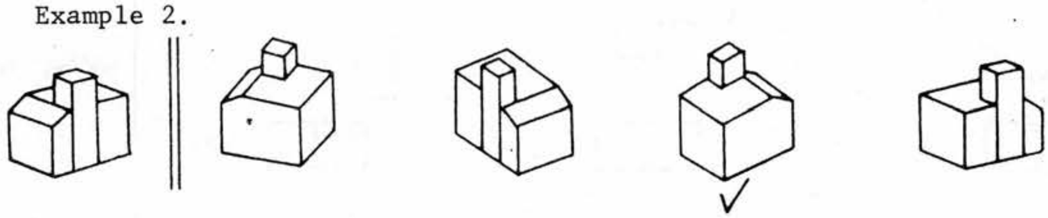


On the left of the double line is the drawing of an object; you can think of it as a small piece of wood fastened to a larger one. On the right of the line are four other drawings; only <u>one</u> of these shows the object correctly, but in a different position: the remaining three are wrong. You have to find which of the four is the correct drawing.

The answer is No.2 on the right of the line; it shows the object turned round and seen from below. We have put a tick (✓) under this drawing. The other answers are wrong. Answer No.1 shows the small piece turned round, and Nos. 3 and 4 have the small piece at the wrong corner of the large piece.

Look at Example 2.

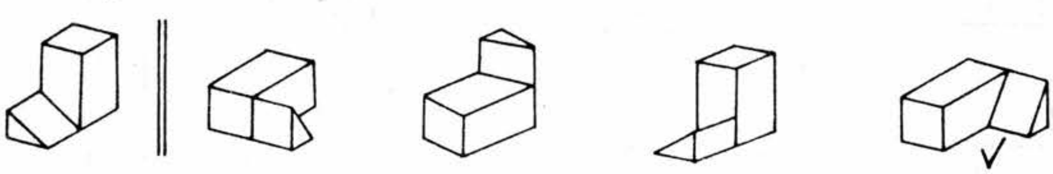
Example 2.



We have put a tick (✓) under No.3 on the right of the line as this is the same as the drawing on the left of the line, when seen from a different position. None of the other three is the same as the drawing on the left of the line.

Look at Example 3.

Example 3.



Note that the object may be shown in any position; as seen from below, turned round, lying on its side, or upside down. But only <u>one</u> drawing on the right of the double line is a <u>correct</u> drawing of the object on the left of this line.

No.4 on the right of the line is the correct answer. See that this is so.

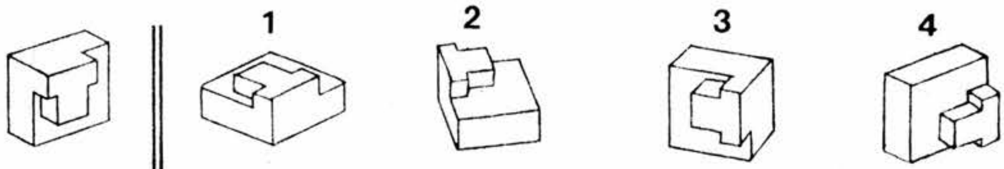
The questions on page 9 are to be answered in the same way. Put a tick (✓) UNDER the correct answer.

GO STRAIGHT ON TO PAGE 9 AND BEGIN AT ONCE

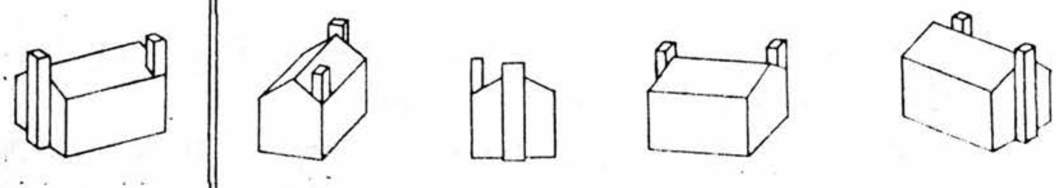
SECTION 3

Do not write in this column.

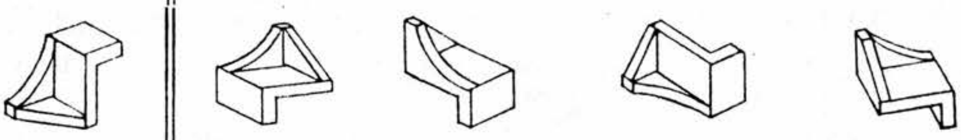
	1	2	3	4	



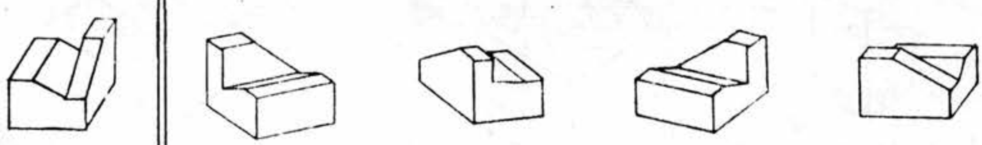
41



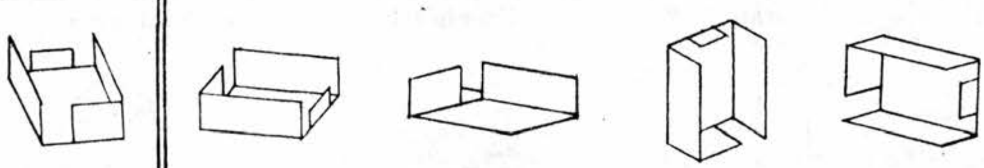
42



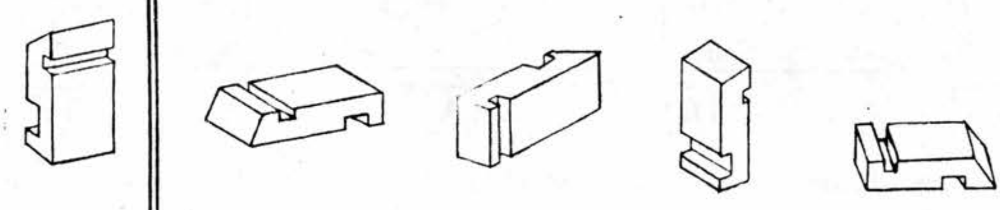
43



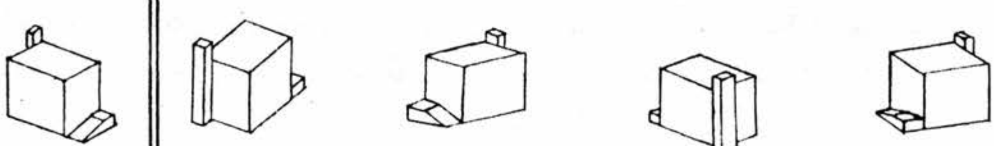
44



45



46

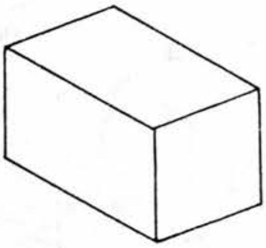


47

LOOK OVER YOUR WORK IN THIS SECTION ONLY TILL TIME IS UP

DO <u>NOT</u> TURN OVER UNTIL YOU ARE TOLD

SECTION 4

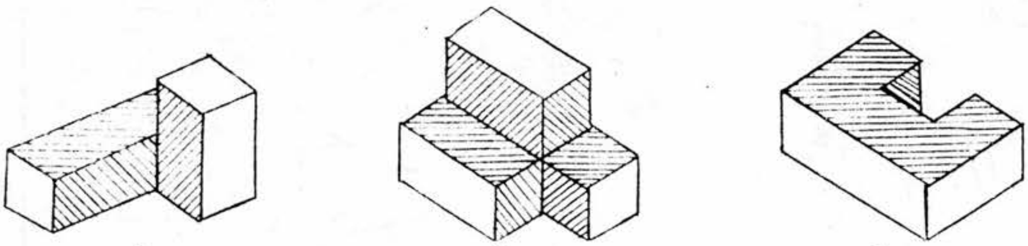


On the left is a drawing of a block. The block has the same height and width; its length is one and a half times each of these.

Now look at the drawings below. Each is a drawing of part of a block of the same size and shape as the one shown above.

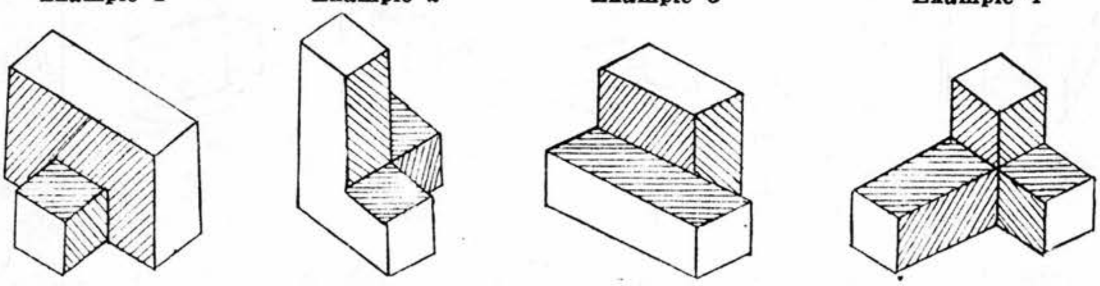
Notice that the three parts above the double line are lettered A, B and C; while the four parts below the double line are numbered 1, 2, 3 and 4.

You have to find which one of the lettered parts will exactly fit each of the numbered parts to make up a block like that at the top of the page.



A **B** **C**

Example 1 **Example 2** **Example 3** **Example 4**



C **B** **A** **B**

Look at Example 1. Part C exactly fits part number 1 to make up the block, so we have written C as the answer. Neither A nor B will fit number 1 exactly.

Look at Example 2. This shows a part standing on end. Part B fits it exactly to make the block, so we have written B as the answer.

NOTE -

(a) The parts may be turned in any way.

(b) The same lettered part may be used in different questions.

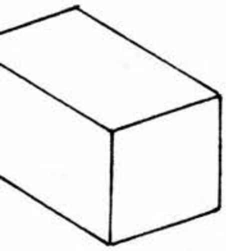
(c) The shading lines show which surfaces will be inside the block when the two parts are fitted together. Pay no attention to the direction of the shading lines.

See that the answer to Example 3 is A and that the answer to Example 4 is B.

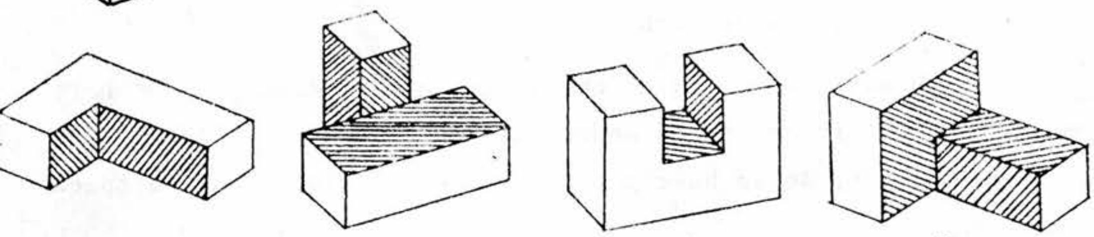
The questions on page 11 are to be answered in the same way. Write ONE letter for each answer.

GO STRAIGHT ON TO PAGE 11 AND BEGIN AT ONCE

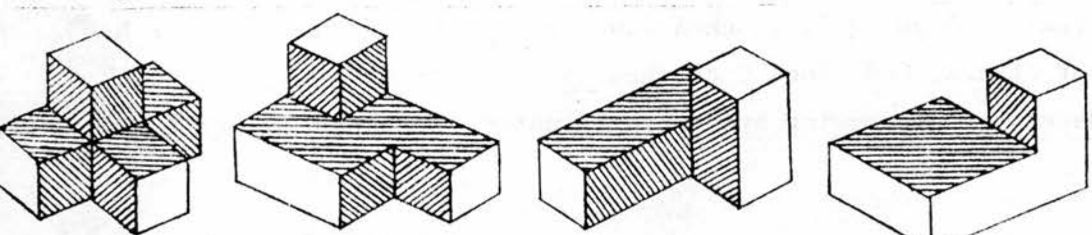
SECTION 4



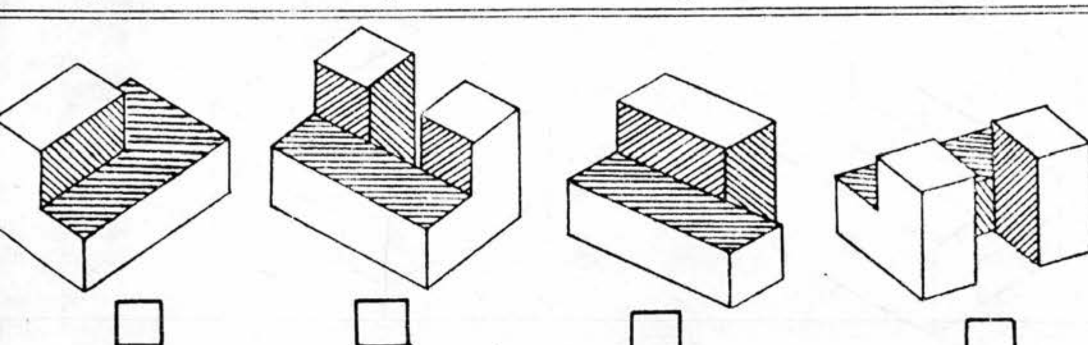
Note that there are eight parts lettered A to H.

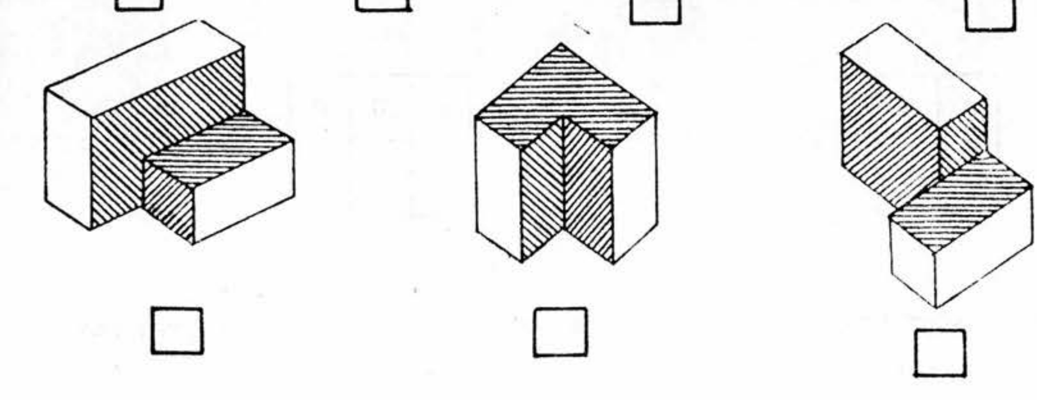


A B C D



E F G H





Do not write in this column.

Punching

A - 1
B - 2
C - 3
D - 4
E - 5
F - 6
G - 7
H - 8

48/49/50/51

52/53/54

LOOK OVER YOUR WORK IN THIS SECTION ONLY TILL TIME IS UP

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SECTION 5

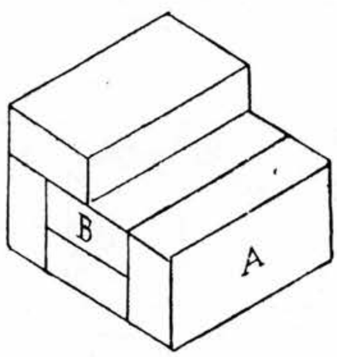
Each of the two drawings below shows a collection of blocks fitted together. These blocks are all of the same size and shape.

Notice that some of the blocks are lettered. You have to find out how many blocks are touched by each of the lettered blocks, and write the answers in the blank spaces underneath.

Examples. In Drawing 1, block A touches two other blocks, so we have put the number 2 below A in the space underneath the drawing. Block B touches four other blocks, so we have put the number 4 below B in the space under the drawing.

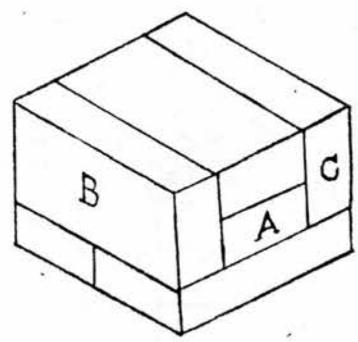
See that in Drawing 2, block A touches five other blocks, block B touches four others, and block C touches four others. Fill up the blank spaces underneath the drawing by writing 5 under A, 4 under B, and 4 under C.

Drawing 1.



A	B
2	4

Drawing 2.



A	B	C

The questions on pages 13 are to be answered in the same way. Write a number in the blank space underneath each letter.

GO STRAIGHT ON TO PAGE 13 AND BEGIN WORK AT ONCE

SECTION 5

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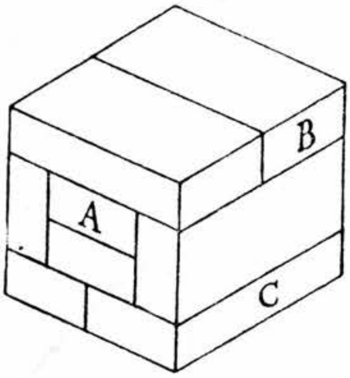
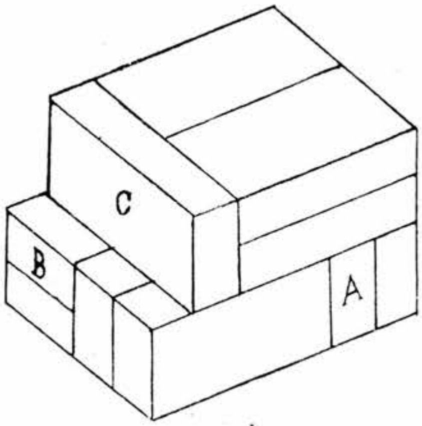


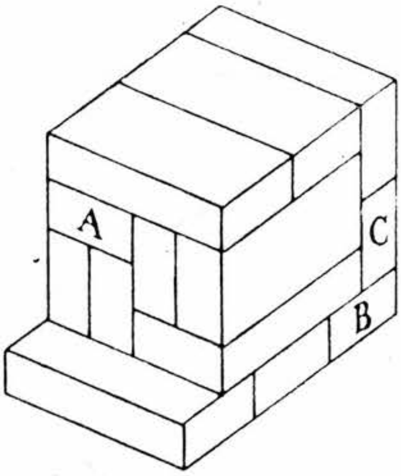
A	B	C

55 56 57



A	B	C

58 59 60



A	B	C

61 62 63

LOOK OVER YOUR WORK IN THIS SECTION ONLY TILL TIME IS UP

How much have you enjoyed this spatial test?
(Please tick the appropriate box)

a lot ☐ a little ☐ not very much ☐

not at all ☐ couldn't say ☐

64

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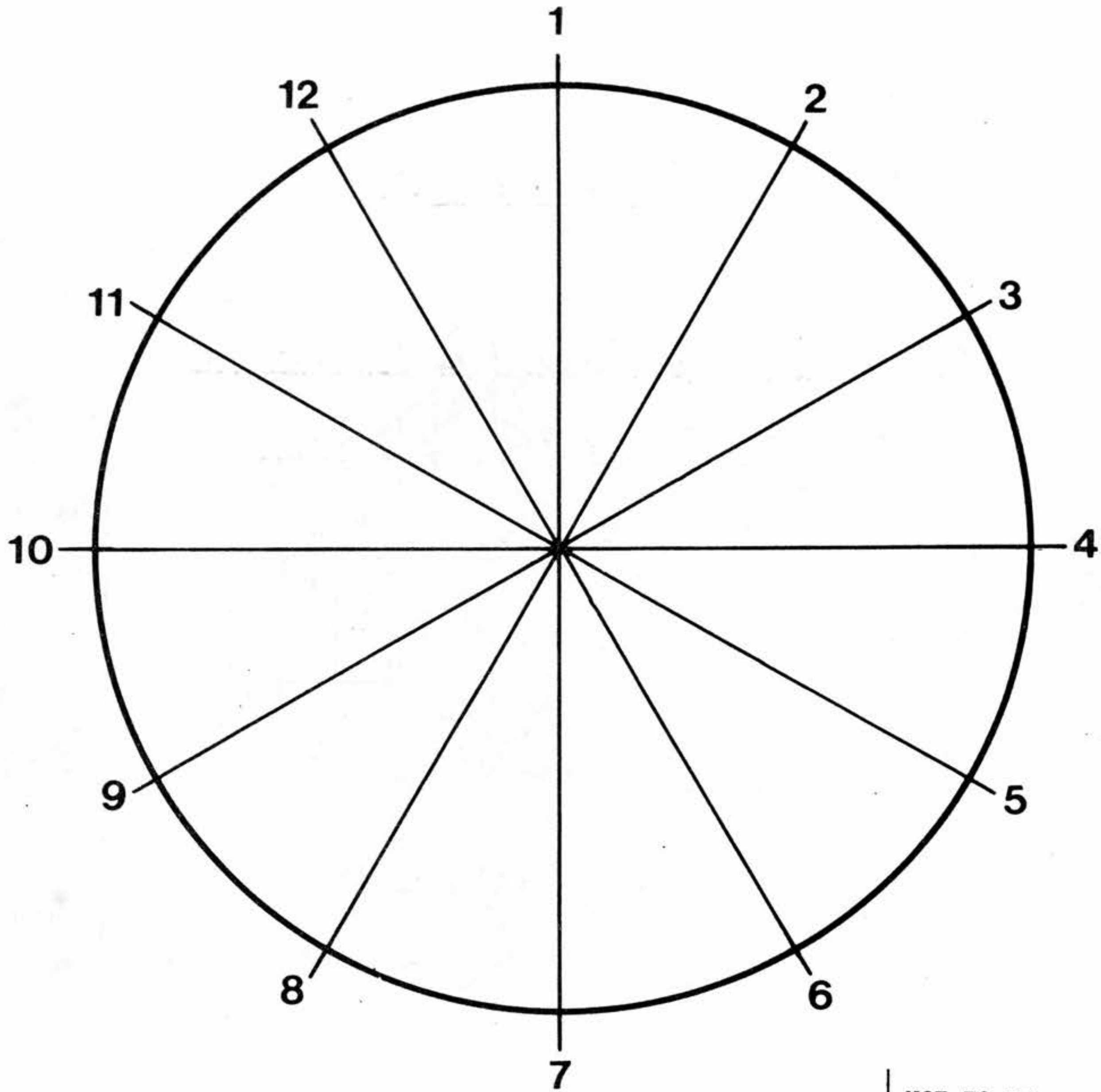
PART 5 DIRECTIONS

This section is concerned with your sense of direction.



Which line points in the direction of:
(insert number of lines in the box)

NOT TO BE FILLED IN BY PUPIL

(a) the zoo ☐ 65

(b) the airport terminal ☐ 67

(c) Woolworths in Corstorphine ☐ 69

(d) the Barnton Hotel (at Barnton traffic circle) ☐ 71

(e) the Forth Road Bridge ☐ 73

A P P E N D I X V I I

ANALYSIS OF VARIANCE TABLES PROJECT ONE

BY QUASI SPATIAL TEST, BY TOTAL

AND THEN BY PRIMARY GROUP

NOTE: INTELLI = SIML + PICT

TABLE A1 PROJECT ONE: ANALYSIS OF VARIANCE ON EFT, TOTAL SAMPLE (n = 140)

EFT, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	511.290	2	255.645	37.395	.001
Age	409.935	1	409.935	59.965	.001
Intelli	201.791	1	201.791	29.518	.001
Main Effects	66.178	2	33.089	4.840	.009
Sex of subject	1.688	1	1.688	0.247	.999
Sex of experimenter	64.348	1	64.348	9.413	.003
2-way Interactions	8.308	1	8.308	1.215	.272
Sex/subj. Sex/exp.	8.308	1	8.308	1.215	.272
Residual	916.062	134	6.836		
Total	1501.838	139	10.805		

TABLE A2 PROJECT ONE: ANALYSIS OF VARIANCE ON EFT, PRIMARY THREE,

(n = 28)

EFT, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	81.867	2	40.933	9.123	.002
Age	16.434	1	16.434	3.663	.066
Intelli	47.756	1	47.756	10.643	.004
Main Effects	3.117	2	1.559	0.347	.999
Sex of subject	2.319	1	2.319	0.517	.999
Sex of experimenter	1.398	1	1.398	0.312	.999
2-way Interactions	3.162	1	3.162	0.705	.999
Sex/subj. Sex/ exp.	3.162	1	3.162	0.705	.999
Residual	98.712	22	4.487		
Total	186.857	27	6.921		

TABLE A3: PROJECT ONE: ANALYSIS OF VARIANCE ON EFT, PRIMARY FOUR, (n = 28)

EFT, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	17.600	2	8.800	2.779	.082
Age	0.164	1	0.164	0.052	.999
Intelli	17.511	1	17.511	5.529	.027
Main Effects	24.610	2	12.305	3.885	.035
Sex of subject	21.285	1	21.285	6.720	.016
Sex of experimenter	2.517	1	2.517	0.795	.999
2-way Interactions	9.362	1	9.362	2.956	.096
Sex/subj. Sex/exp.	9.362	1	9.362	2.956	.096
Residual	69.678	22	3.167		
Total	121.250	27	4.491		

TABLE A4: PROJECT ONE: ANALYSIS OF VARIANCE ON EFT, PRIMARY FIVE, (n = 28)

EFT, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	38.403	2	19.202	2.270	.125
Age	14.262	1	14.262	1.686	.205
Intelli.	28.495	1	28.495	3.369	.077
Main effects	88.074	2	44.037	5.206	.014
Sex of subject	33.114	1	33.114	3.915	.058
Sex of experimenter	49.970	1	49.970	5.908	.022
2-way Interactions	30.403	1	30.403	3.594	.068
Sex/subj. Sex/exp.	30.403	1	30.403	3.594	.068
Residual	186.083	22	8.458		
Total	342.963	27	12.702		

TABLE A5: PROJECT ONE: ANALYSIS OF VARIANCE ON EFT, PRIMARY SIX

(n = 28)

EFT, by sex of subject, sex of experimenter with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	15.617	2	7.808	1.005	.384
Age	2.823	1	2.823	0.363	.999
Intelli.	11.848	1	11.848	1.525	.228
Main Effects	13.120	2	6.560	0.845	.999
Sex of subjects	10.202	1	10.202	1.314	.263
Sex of experimenter	2.955	1	2.955	0.381	.999
2-way Interactions	2.248	1	2.248	0.289	.999
Sex/subj. Sex/exp.	2.248	1	2.248	0.289	.999
Residual	170.872	22	7.767		
Total	201.857	27	7.476		

TABLE A6: PROJECT ONE: ANALYSIS OF VARIANCE ON EFT, PRIMARY SEVEN

(n = 28)

EFT, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	128.538	2	64.269	10.858	.001
Age	13.804	1	13.804	2.332	.138
Intelli.	63.162	1	63.162	10.671	.004
Main Effects	9.297	2	4.648	0.785	.999
Sex of subject	5.241	1	5.241	0.885	.999
Sex of experimenter	5.709	1	5.709	0.965	.999
2-way Interactions	10.911	1	10.911	1.843	.186
Sex/subj. Sex/exp.	10.911	1	10.911	1.843	.186
Residual	130.218	22	5.919		
Total	278.964	27	10.332		

TABLE A7: PROJECT ONE: ANALYSIS OF VARIANCE ON MAZE, TOTAL SAMPLE, (n = 140)

MAZE, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	120.588	2	60.294	16.485	.001
Age	106.731	1	106.731	29.181	.001
Intelli.	34.424	1	34.424	9.412	.003
Main Effects	12.832	2	6.416	1.754	.175
Sex of subject	0.682	1	0.682	0.186	.999
Sex of experimenter	12.188	1	12.188	3.332	.067
2-way Interactions	0.644	1	0.644	0.176	.999
Sex/subj. Sex/exp.	0.644	1	0.644	0.176	.999
Residual	490.111	134	3.658		
Total	624.175	139	4.490		

TABLE A8: PROJECT ONE: ANALYSIS OF VARIANCE ON MAZE, PRIMARY THREE, (n = 28)

MAZE, by sex of subject, sex of experimenter, with age, intelligence.

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F.
Covariates	21.463	2	10.731	2.448	.108
Age	1.231	1	1.231	0.281	.999
Intelli.	16.904	1	16.904	3.855	.059
Main Effects	4.323	2	2.161	0.493	.999
Sex of subject	0.955	1	0.955	0.218	.999
Sex of experimenter	3.979	1	3.979	0.907	.999
2-way Interactions	7.783	1	7.783	1.775	.194
Sex/subj. Sex/exp.	7.783	1	7.783	1.775	.194
Residual	96.458	22	4.384		
Total	130.027	27	4.816		

TABLE A9: PROJECT ONE: ANALYSIS OF VARIANCE ON MAZE, PRIMARY FOUR

(n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	17.064	2	8.532	2.602	.095
Age	11.944	1	11.944	3.643	.066
Intelli.	4.726	1	4.726	1.441	.241
Main Effects	1.617	2	0.808	0.247	.999
Sex of subject	0.573	1	0.573	0.175	.999
Sex of experimenter	0.964	1	0.964	0.294	.999
2-way Interactions	0.347	1	0.347	0.106	.999
Sex/subj. Sex/exp.	0.347	1	0.347	0.106	.999
Residual	72.142	22	3.279		
Total	91.170	27	3.377		

TABLE A10: PROJECT ONE: ANALYSIS OF VARIANCE ON MAZE, PRIMARY FIVE, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	8.781	2	4.390	1.979	.161
Age	8.284	1	8.284	3.734	.063
Intelli.	0.121	1	0.121	0.055	.999
Main Effects	0.550	2	0.275	0.124	.999
Sex of subject	0.136	1	0.136	0.061	.999
Sex of experimenter	0.440	1	0.440	0.199	.999
2-way Interactions	0.101	1	0.101	0.045	.999
Sex/subj. Sex/exp.	0.101	1	0.101	0.045	,999
Residual	48.809	22	2.219		
Total	58.241	27	2.157		

TABLE A11: PROJECT ONE: ANALYSIS OF VARIANCE ON MAZE, PRIMARY SIX

(n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	2.461	2	1.230	0.338	.999
Age	0.416	1	0.416	0.114	.999
Intelli.	2.172	1	2.172	0.597	.999
Main Effects	25.577	2	12.788	3.516	.046
Sex of subject	2.232	1	2.232	0.614	.999
Sex of experimenter	23.394	1	23.394	6.431	.018
2-way Interactions	15.680	1	15.680	4.311	.047
Sex/subj. Sex/exp.	15.680	1	15.680	4.311	.047
Residual	80.023	22	3.637		
Total	123.741	27	4.583		

TABLE A12: PROJECT ONE: ANALYSIS OF VARIANCE ON MAZE, PRIMARY SEVEN (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	33.617	2	16.808	8.065	.003
Age	0.123	1	0.123	0.059	.999
Intelli.	28.530	1	28.530	13.690	.002
Main Effects	6.493	2	3.247	1.558	.232
Sex of subject	0.007	1	0.007	0.003	.999
Sex of experimenter	6.354	1	6.354	3.049	.091
2-way Interactions	2.719	1	2.719	1.304	.265
Sex/subj. Sex/exp.	2.719	1	2.719	1.304	.265
Residual	45.850	22	2.084		
Total	88.678	27	3.284		

TABLE A13: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, TOTAL SAMPLE,

(n = 140)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	167.319	2	83.660	20.130	.001
Age	161.481	1	161.481	38.856	.001
Intelli.	26.065	1	26.065	6.272	.013
Main Effects	56.636	2	28.318	6.814	.002
Sex of subject	23.555	1	23.555	5.668	.018
Sex of experimenter	32.710	1	32.710	7.871	.006
2-way Interactions	0.023	1	0.023	0.006	.999
Sex/subj. Sex/exp.	0.023	1	0.023	0.006	.999
Residual	556.896	134	4.156		
Total	780.875	139	5.618		

TABLE A14: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, PRIMARY THREE, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1.102	2	0.551	0.205	.999
Age	0.465	1	0.465	0.173	.999
Intelli.	0.876	1	0.876	0.325	.999
Main Effects	2.491	2	1.245	0.462	.999
Sex of subject	0.062	1	0.062	0.023	.999
Sex of experimenter	2.486	1	2.486	0.923	.999
2-Way Interactions	6.391	1	6.391	2.373	.134
Sex/subj. Sex/exp.	6.391	1	6.391	2.372	.134
Residual	59.266	22	2.694		
Total	69.250	27	2.565		

TABLE A15: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, PRIMARY FOUR, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	3.878	2	1.939	0.431	.999
Age	0.117	1	0.117	0.026	.999
Intelli.	3.792	1	3.792	0.844	.999
Main Effects	21.053	2	10.527	2.342	.118
Sex of subject	4.533	1	4.533	1.009	.328
Sex of experimenter	15.610	1	15.610	3.473	.073
2-way Interactions	7.442	1	7.442	1.656	.209
Sex/subj. Sex/exp.	7.442	1	7.442	1.656	.209
Residual	98.877	22	4.494		
Total	131.250	27	4.861		

TABLE A16: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, PRIMARY FIVE. (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	14.390	2	7.195	1.632	.217
Age	0.944	1	0.944	0.214	.999
Intelli.	12.395	1	12.395	2.812	.104
Main Effects	29.017	2	14.509	3.292	.055
Sex of subject	11.871	1	11.871	2.693	.112
Sex of experimenter	15.484	1	15.484	3.513	.071
2-way Interactions	0.589	1	0.589	0.134	.999
Sex/subj. Sex/exp.	0.589	1	0.589	0.134	.999
Residual	96.969	22	4.408		
Total	140.964	27	5.221		

TABLE A17: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, PRIMARY SIX, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	5.520	2	2.760	0.566	.999
Age	5.512	1	5.512	1.130	.300
Intelli.	0.007	1	0.007	0.001	.999
Main Effects	2.221	2	1.110	0.228	.999
Sex of subject	0.861	1	0.861	0.176	.999
Sex of experimenter	1.353	1	1.353	0.277	.999
2-way Interactions	3.614	1	3.614	0.741	.999
Sex/subj. Sex/exp.	3.614	1	3.614	0.741	.999
Residual	107.324	22	4.878		
Total	118.678	27	4.395		

TABLE A 18: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, PRIMARY SEVEN (n = 28)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	45.771	2	22.886	11.963	.001
Age	4.810	1	4.810	2.514	.124
Intelli.	45.002	1	45.002	23.523	.001
Main Effects	60.697	2	30.349	15.864	.001
Sex of subject	38.617	1	38.617	20.186	.001
Sex of experimenter	12.371	1	12.371	6.467	.018
2-way Interactions	16.301	1	16.301	8.521	.008
Sex/subj, Sex/exp.	16.301	1	16.301	8.521	.008
Residual	42.088	22	1.913		
Total	164.857	27	6.106		

TABLE A19: PROJECT ONE: ANALYSIS OF VARIANCE ON MAP 1, PRIMARY THREE TO SIX, (n = 112)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	122.934	2	61.467	14.716	.001
Age	122.930	1	122.930	29.431	.001
Intelli.	4.457	1	4.457	1.067	.305
Main Effects	16.908	2	8.454	2.024	.135
Sex of subject	5.456	1	5.456	1.306	.255
Sex of experimenter	10.754	1	10.754	2.575	.107
2-way Interactions	1.372	1	1.372	0.328	.999
Sex/subj. Sex/exp.	1.372	1	1.372	0.328	.999
Residual	442.743	106	4.177		
Total	583.958	111	5.261		

TABLE A20: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPLACE 1, TOTAL SAMPLE (n = 140)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF.OF F
Covariates	23528.051	2	11764.023	15.204	.001
Age	21942.090	1	21942.090	28.359	.001
Intelli.	5026.273	1	5026.273	6.496	.012
Main Effects	2391.523	2	1195.762	1.545	.215
Sex of subject	935.300	1	935.300	1.209	.273
Sex of experimenter	1440.666	1	1440.666	1.862	.171
2-way Interactions	3.285	1	3.285	0.004	.999
Sex/subj. Sex/exp.	3.285	1	3.285	0.004	.999
Residual	103680.250	134	773.733		
Total	129603.125	139	932.396		

TABLE A21: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPLACE 1, PRIMARY THREE (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1921.819	2	960.909	0.722	.999
Age	189.552	1	189.552	0.142	.999
Intelli.	1385.497	1	1385.497	1.041	.320
Main Effects	2906.880	2	1453.440	1.092	.354
Sex of subject	479.739	1	479.739	0.360	.999
Sex of experimenter	2774.572	1	2774.572	2.084	.160
2-way Interactions	908.340	1	908.340	0.682	.999
Sex/subj. Sex/exp.	908.337	1	908.337	0.682	.999
Residual	29285.723	22	1331.169		
Total	35022.762	27	1297.139		

TABLE A22: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPLACE 1, PRIMARY FOUR (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	821.500	2	410.750	0.595	.999
Age	635.021	1	635.021	0.920	.999
Intelli.	169.274	1	169.274	0.245	.999
Main Effects	1373.399	2	686.700	0.995	.999
Sex of subject	1075.633	1	1075.633	1.558	.223
Sex of experimenter	242.286	1	242.286	0.351	.999
2-way Interactions	117.582	1	117.582	0.170	.999
Sex/subj. Sex/exp.	117.582	1	117.582	0.170	.999
Residual	15186.430	22	690.292		
Total	17498.914	27	648.108		

TABLE A23: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPLACE 1,

PRIMARY FIVE (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	683.633	2	341.816	0.516	.999
Age	621.331	1	621.331	0.939	.999
Intelli.	118.376	1	118.376	0.179	.999
Main Effects	629.617	2	314.808	0.476	.999
Sex of subject	56.130	1	56.130	0.085	.999
Sex of experimenter	551.083	1	551.083	0.833	.999
2-Way Interactions	24.907	1	24.907	0.038	.999
Sex/subj. Sex/exp.	24.907	1	24.907	0.038	.999
Residual	14562.121	22	661.915		
Total	15900.281	27	588.899		

TABLE A24: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPLACE 1,

PRIMARY SIX, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	5756.445	2	2878.223	4.236	.027
Age	26.815	1	26.815	0.039	.999
Intelli.	5640.121	1	5640.121	8.301	.009
Main Effects	144.027	2	72.014	0.106	.999
Sex of subject	16.681	1	16.681	0.025	.999
Sex of experimenter	127.658	1	127.658	0.188	.999
2-way Interactions	353.043	1	353.043	0.520	.999
Sex/subj. Sex/exp.	353.046	1	353.046	0.520	.999
Residual	14947.871	22	679.448		
Total	21201.387	27	785.236		

TABLE A25: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPLACE1, PRIMARY SEVEN (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	915.282	2	457.641	0.890	.999
Age	184.620	1	184.620	0.359	.999
Intelli.	915.253	1	915.253	1.781	.193
Main Effects	3786.323	2	1893.162	3.683	.041
Sex of subject	3695.093	1	3695.093	7.189	.013
Sex of experimenter	408.978	1	408.978	0.796	.999
2-Way Interactions	3292.547	1	3292.547	6.406	.018
Sex/subj. Sex/exp.	3292.548	1	3292.548	6.406	.018
Residual	11307.859	22	513.993		
Total	19302.012	27	714.889		

TABLE A26: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPDIRE, TOTAL SAMPLE (n = 140)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	13798.723	2	6899.359	4.173	.017
Age	9929.125	1	9929.125	6.006	.015
Intelli.	6768.523	1	6768.523	4.094	.043
Main Effects	13175.730	2	6587.863	3.985	.020
Sex of subject	2108.433	1	2108.433	1.275	.260
Sex of experimenter	11001.602	1	11002.602	6.655	.011
2-Way Interactions	5698.473	1	5698.473	3.447	.062
Sex/subj. Sex/exp.	5698.469	1	5698.469	3.447	.062
Residual	221542.812	134	1653.304		
Total	254215.750	139	1828.890		

TABLE A27: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPDIRE, PRIMARY THREE, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	943.781	2	471.891	0.374	.999
Intelli.	480.573	1	480.573	0.381	.999
Age	248.724	1	248.724	0.197	.999
Main Effects	692.607	2	346.303	0.274	.999
Sex of subject	0.000	1	0.000	0.000	.999
Sex of experimenter	664.370	1	664.370	0.526	.999
2-way Interactions	1616.903	1	1616.903	1.281	0.270
Sex/subj. Sex/exp.	1616.903	1	1616.903	1.281	0.270
Residual	27778.016	22	1262.637		
Total	31031.309	27	1149.308		

TABLE A28: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPDIRE, PRIMARY FOUR (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1051.113	2	525.556	0.488	.999
Intelli.	248.050	1	248.050	0.230	.999
Age	780.013	1	780.013	0.725	.999
Main Effects	2006.724	2	1003.362	0.932	.999
Sex of subject	1948.332	1	1948.332	1.810	.189
Sex of experimenter	29.016	1	29.016	0.027	.999
2-Way Interactions	402.344	1	402.344	0.374	.999
Sex/subj. Sex/exp.	402.344	1	402.344	0.374	.999
Residual	23684.758	22	1076.580		
Total	27144.941	27	1005.368		

TABLE A29: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPDIRE, PRIMARY FIVE (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	11016.918	2	5508.457	2.573	.097
Intelli.	10123.809	1	10123.809	4.728	.039
Age	301.556	1	301.556	0.141	.999
Main Effects	7458.156	2	3729.078	1.742	.197
Sex of subject	2593.062	1	2593.062	1.211	.283
Sex of experimenter	4448.121	1	4448.121	2.077	.160
2-Way Interactions	4121.441	1	4121.441	1.925	.176
Sex/subj. Sex/exp.	4121.441	1	4121.441	1.925	.176
Residual	47104.109	22	2141.096		
Total	69700.625	27	2581.504		

TABLE A30: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPDIRE, PRIMARY SIX, (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF.OF F
Covariates	12943.492	2	6471.746	2.594	.096
Intelli.	11522.852	1	11522.852	4.618	.041
Age	877.068	1	877.068	0.352	.999
Main Effects	663.637	2	331.818	0.133	.999
Sex of subject	236.617	1	236.617	0.095	.999
Sex of experimenter	429.197	1	429.197	0.172	.999
2-Way Interactions	3790.012	1	3790.012	1.519	.229
Sex/subj. Sex/exp.	3790.010	1	3790.010	1.519	.229
Residual	54891.234	22	2495.056		
Total	72288.375	27	2677.347		

TABLE A 31: PROJECT ONE: ANALYSIS OF VARIANCE ON COMPDIRE, PRIMARY SEVEN (n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	4180.348	2	2090.174	1.448	.256
Intelli.	2601.928	1	2601.928	1.802	.190
Age	167.581	1	167.581	0.116	.999
Main Effects	7666.246	2	3833.123	2.655	.091
Sex of subject	2454.894	1	2454.894	1.700	.203
Sex of experimenter	3870.486	1	3870.486	2.680	.112
2-Way Interactions	294.727	1	294.727	0.204	.999
Sex/subj. Sex/exp.	294.725	1	294.725	0.204	.999
Residual	31767.156	22	1443.961		
Total	43908.477	27	1626.240		

TABLE A32: PROJECT ONE: KEOGH'S COMPARISONS BETWEEN BOYS' AND GIRLS' SCORES ON PATTERN WALKING AND DRAWING (n = 135, 45 in each condition, 25 boys and 20 girls)

		WALKING				DRAWING			
CONDITION		BOYS	GIRLS	t	PROB. LEVEL	BOYS	GIRLS	t	PROB. LEVEL
Floor									
Simple[2]	mean	12.60	11.05	1.96	.05[1]*	12.92	13.00	n.g.	n.s.
	s.d.	1.98	1.28			1.73	0.86		
Complex	mean	12.20	12.35	0.22	n.s.	15.40	15.40	n.g.	n.s.
	s.d.	2.52	1.79			1.78	1.31		
Total	mean	24.80	23.40	1.38	n.s.	28.32	28.40	n.g.	n.s.
	s.d.	3.76	2.62			2.87	1.71		

* = p $\leq$ .01

1. This is reported as significant at the .01 level by Keogh but this is clearly an error.
2. Simple patterns are patterns 1 - 4 (see pp 100-101) complex patterns are patterns 5 - 9

n.g. not given n.s. not significant

TABLE A32 (cont.)

		WALKING				DRAWING			
CONDITION		BOYS	GIRLS	t	PROB. LEVEL	BOYS	GIRLS	t	PROB. LEVEL
Mat									
Simple	mean	12.84	10.95	3.28	.01 **	13.16	13.10	n.g.	n.s.
	s.d.	2.17	1.43			1.11	1.55		
Complex	mean	13.72	12.75	1.43	n.s.	15.04	15.20	n.g.	n.s.
	s.d.	2.34	2.05			1.99	1.80		
Total	mean	26.56	23.70	2.49	.02*	28.20	28.30	n.g.	n.s.
	s.d.	4.05	3.31			2.71	2.81		

* $p \leq .05$ n.g. not given n.s. not significant

** $p \leq .01$

TABLE A32: (cont.)

CONDITION		WALKING BOYS	WALKING GIRLS	WALKING t	WALKING PROB. LEVEL	DRAWING BOYS	DRAWING GIRLS	DRAWING t	DRAWING PROB. LEVEL
Sand									
Simple	mean	13.44	11.25	3.93	.01**	13.44	12.15	n.g.	n.s.
	s.d.	1.58	2.07			1.45	1.60		
Complex	mean	14.64	12.85	2.32	n.s.	15.08	14.65	n.g.	n.s.
	s.d.	2.64	2.35			1.87	1.87		
Total	mean	28.08	24.10	3.20	.01**	28.52	26.80	n.g.	n.s.
	s.d.	3.91	4.10			2.63	3.04		

** $p \leq .01$ n.g. not given n.s. not significant

Table A32 taken from Keogh, 1971, p. 30.

TABLE A33: PROJECT ONE: COMPARISON BETWEEN BOYS' AND GIRLS' SCORES ON PATTERN DRAWING AND PATTERN WALKING ($n = 28$; boys = 14 and girls = 14)

CONDITION		WALKING				DRAWING			
Chalk (similar to 'Sand')		BOYS	GIRLS	t	PROB. LEVEL	BOYS	GIRLS	t	PROB. LEVEL
Simple	mean	10.50	9.71	.88	n.s.	10.50	8.57	2.59	.02*
	s.d.	2.59	2.09			1.79	2.14		
Complex	mean	11.79	10.36	1.35	n.s.	11.14	8.86	2.33	.03*
	s.d.	3.14	2.40			2.98	2.14		
Total	mean	22.29	20.07	1.34	n.s.	21.64	17.43	3.51	.002**
	s.d.	5.58	2.70			3.41	2.92		

** $p \leq .01$ * $p \leq .05$ n.s. not significant

TABLE A34: PROJECT ONE: COMPARISON BETWEEN DRAWING AND WALKING WITHIN SEXES (n = 28, boys = 14, girls = 14)

	WALKING		DRAWING			
BOYS	mean	s.d.	mean	s.d.	t	prob. level
Simple	10.50	2.59	10.50	1.79	0.0	n.s.
Complex	11.79	3.14	11.14	2.98	0.55	n.s.
Total	22.29	5.58	21.64	3.41	0.38	n.s.
GIRLS						
Simple	9.71	2.09	8.57	2.14	1.58	n.s.
Complex	10.36	2.40	8.86	2.14	2.07	n.s.
Total	20.07	2.70	17.43	2.92	2.79	.02*

* $p \leq .05$ n.s. not significant

TABLE A35: PROJECT ONE: STYLE OF WALKING PATTERNS: COMPARISONS BETWEEN SEXES (n = 28, boys = 14 and girls = 14)

	BOYS	GIRLS
Subject indicates clearly when pattern completed:	13	13
Subject made patterns in subunits:	11	13
Subject walked hesitantly:	2	5

TABLE A36: PROJECT ONE FACTOR ANALYSIS: ROTATION OF THE PRINCIPAL COMPONENT ANALYSIS GIVEN IN TABLE 11 (p) OBLIQUE ROTATION, TOTAL SAMPLE (n = 140)

	FACTOR 1	FACTOR 2
EFT	.632	.258
MAZE	.789	-.254
COMPLACE 2	.156	.679
COMPDIRE	-.095	.857
MAP 2	.470	.336
SIML	.718	.161
PICT	.806	-.022

ANALYSIS OF VARIANCE TABLES

PROJECT TWO

BY TEST, BY TOTAL AND BY YEAR

TABLE A37: PROJECT TWO: ANALYSIS OF VARIANCE ON MS1, TOTAL SAMPLE (n = 190)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	492.294	2	246.147	20.493	.001
Age	72.648	1	72.648	6.048	.014
AH4	372.731	1	372.731	31.032	.001
Main Effects	50.332	1	50.332	4.190	.040
Sex	50.331	1	50.331	4.190	.040
Residual	2234.094	186	12.011		
Total	2776.720	189	14.692		

TABLE A38: PROJECT TWO: ANALYSIS OF VARIANCE ON MS1, YEAR ONE (n = 27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	101.850	2	50.925	3.869	.035
Age	8.152	1	8.152	0.619	.999
AH4	41.650	1	41.650	3.164	.085
Main Effects	13.256	1	13.256	1.007	.328
Sex	13.256	1	13.256	1.007	.328
Residual	302.745	23	13.163		
Total	417.851	26	16.071		

TABLE A39: PROJECT TWO: ANALYSIS OF VARIANCE ON MS1, YEAR TWO (n = 53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	199.321	2	99.661	10.351	.001
Age	3.531	1	3.531	0.367	.999
AH4	189.895	1	189.895	19.723	.001
Main Effects	3.008	1	3.008	0.312	.999
Sex	3.008	1	3.001	0.312	.999
Residual	471.780	49	9.628		
Total	674.110	52	12,964		

TABLE A40: PROJECT TWO: ANALYSIS OF VARIANCE ON MS1, YEAR THREE.

(n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	68.761	2	34.380	2.556	.097
Age	14.180	1	14.180	1.054	.316
AH4	30.234	1	30.234	2.247	.143
Main Effects	23.614	1	23.614	1.755	.195
Sex	23.614	1	23.614	1.755	.195
Residual	322.873	24	13.453		
Total	415.248	27	15.380		

TABLE A41: PROJECT TWO: ANALYSIS OF VARIANCE ON MS1, YEAR FOUR (n=51)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	66.331	2	33.166	3.148	.051
Age	8.345	1	8.345	0.792	.999
AH4	54.976	1	54.976	5.218	.026
Main Effects	46.646	1	46.646	4.427	.039
Sex	46.646	1	46.646	4.427	.039
Residual	495.175	47	10.536		
Total	608.153	50	12.163		

TABLE A42: PROJECT TWO: ANALYSIS OF VARIANCE ON MS1, YEAR FIVE

(n = 31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	47.182	2	23.591	1.586	.222
Age	0.072	1	0.072	0.005	.999
AH4	44.263	1	44.263	2.976	.092
Main Effects	33.213	1	33.213	2.233	.143
Sex	33.213	1	33.213	2.233	.143
Residual	401.538	27	14.872		
Total	481.933	30	16.064		

TABLE A43: PROJECT TWO: ANALYSIS OF VARIANCE ON MS2, TOTAL SAMPLE

(n = 190)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1562.472	2	781.236	32.907	.001
Age	187.695	1	187.695	7.906	.005
AH4	1235.698	1	1235.698	52.049	.001
Main Effects	58.192	1	58.192	2.451	.115
Sex	58.192	1	58.192	2.451	.115
Residual	4415.809	186	23.741		
Total	6036.477	189	31.939		

TABLE A44: PROJECT TWO: ANALYSIS OF VARIANCE ON MS2, YEAR ONE (n=27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	238.403	2	119.202	4.218	.027
Age	1.654	1	1.654	0.059	.999
AH4	145.646	1	145.646	5.154	.031
Main Effects	19.506	1	19.506	0.690	.999
Sex	19.506	1	19.506	0.690	.999
Residual	649.940	23	28.258		
Total	907.849	26	34.917		

TABLE A45: PROJECT TWO: ANALYSIS OF VARIANCE ON MS2, YEAR TWO (n=53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	679.781	2	339.890	13.921	.001
Age	44.343	1	44.343	1.816	.181
AH4	673.736	1	673.736	27.595	.001
Main Effects	1.208	1	1.208	0.049	.999
Sex	1.208	1	1.208	0.049	.999
Residual	1196.327	49	24.415		
Total	1877.316	52	36.102		

TABLE A46: PROJECT TWO: ANALYSIS OF VARIANCE ON MS2, YEAR THREE (n=28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	324.442	2	162.221	9.320	.001
Age	151.283	1	151.283	8.692	.007
AH4	60.035	1	60.035	3.449	.072
Main Effects	119.270	1	119.270	6.853	.014
Sex	119.270	1	119.270	6.853	.014
Residual	417.716	24	17.405		
Total	861.427	27	31.905		

TABLE A47: PROJECT TWO: ANALYSIS OF VARIANCE ON MS2, YEAR FOUR, (n=51)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	172.112	2	86.056	5.547	.007
Age	13.619	1	13.619	0.878	.999
AH4	151.972	1	151.972	9.796	.003
Main Effects	141.687	1	141.687	9.133	.004
Sex	141.687	1	141.687	9.133	.004
Residual	729.178	47	15.514		
Total	1042.977	50	20.860		

TABLE A48: PROJECT TWO: ANALYSIS OF VARIANCE ON MS2, YEAR FIVE(n = 31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	169.037	2	84.519	4.058	.028
Age	23.064	1	23.064	1.107	.303
AH4	167.733	1	167.733	8.054	.008
Main Effects	60.189	1	60.189	2.890	.097
Sex	60.189	1	60.189	2.890	.097
Residual	562.320	27	20.827		
Total	791.546	30	26.385		

TABLE A49: PROJECT TWO: ANALYSIS OF VARIANCE ON MS3, TOTAL SAMPLE

(n=190)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	56.221	2	28.111	9.587	.001
Age	0.070	1	0.070	0.024	.999
AH4	54.860	1	54.860	18.710	.001
Main Effects	30.829	1	30.829	10.514	.002
Sex	30.829	1	30.829	10.514	.002
Residual	545.377	186	2.932		
Total	632.428	189	3.346		

TABLE A50: PROJECT TWO: ANALYSIS OF VARIANCE ON MS3, YEAR ONE (n=27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	4.278	2	2.139	0.744	.999
Age	0.175	1	0.175	0.061	.999
AH4	3.671	1	3.671	1.277	.270
Main Effects	0.773	1	0.773	0.269	.999
Sex	0.773	1	0.773	0.269	.999
Residual	66.134	23	2.875		
Total	71.185	26	2.738		

TABLE A51: PROJECT TWO: ANALYSIS OF VARIANCE ON MS3, YEAR TWO (n=53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	41.282	2	20.641	7.314	.002
Age	1.821	1	1.821	0.645	.999
AH4	29.474	1	29.474	10.444	.002
Main Effects	1.182	1	1.182	0.419	.999
Sex	1.182	1	1.182	0.419	.999
Residual	138.291	49	2.822		
Total	180.754	52	3.476		

TABLE A52: PROJECT TWO: ANALYSIS OF VARIANCE ON MS3, YEAR THREE (n=28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	17.117	2	8.558	2.642	.090
Age	3.719	1	3.719	1.148	.295
AH4	7.296	1	7.296	2.252	.143
Main Effects	6.387	1	6.387	1.972	.170
Sex	6.387	1	6.387	1.972	.170
Residual	77.746	24	3.239		
Total	101.250	27	3.750		

TABLE A53: PROJECT TWO: ANALYSIS OF VARIANCE ON MS3, YEAR FOUR (n=51)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	17.346	2	8.673	3.059	.055
Age	1.109	1	1.109	0.391	.999
AH4	16.717	1	16.717	5.896	.018
Main Effects	18.816	1	18.816	6.637	.013
Sex	18.816	1	18.816	6.637	.013
Residual	133.249	47	2.835		
Total	169.411	50	3.388		

TABLE A54: PROJECT TWO: ANALYSIS OF VARIANCE ON MS3, YEAR FIVE (n=31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	3.081	2	1.540	0.772	.999
Age	0.265	1	0.265	0.133	.999
AH4	2.133	1	2.133	1.070	.331
Main Effects	38.809	1	38.809	19.458	.001
Sex	38.809	1	38.809	19.458	.001
Residual	53.852	27	1.995		
Total	95.742	30	3.191		

TABLE A55: PROJECT TWO: ANALYSIS OF VARIANCE ON MS4, TOTAL SAMPLE

(n = 190)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	54,233	2	27,116	5.534	.005
Age	16.358	1	16.358	3.339	.066
AH4	31.594	1	31.594	6.448	.012
Main Effects	16.201	1	16.201	3.307	.067
Sex	16.201	1	16.201	3.307	.067
Residual	911.317	186	4.900		
Total	981.751	189	5.194		

TABLE A56: PROJECT TWO: ANALYSIS OF VARIANCE ON MS4, YEAR ONE (n=28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	6.386	2	3.193	0.477	.999
Age	3.560	1	3.560	0.531	.999
AH4	0.120	1	0.120	0.018	.999
Main Effects	0.209	1	0.209	0.031	.999
Sex	0.209	1	0.209	0.031	.999
Residual	154.072	23	6.699		
Total	160.666	26	6.179		

TABLE A57: PROJECT TWO: ANALYSIS OF VARIANCE ON MS4, YEAR TWO (n=53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	41.282	2	20.641	4.453	.017
Age	15.702	1	15.702	3.388	.068
AH4	37.394	1	37.394	8.067	.006
Main Effects	2.421	1	2.421	0.522	.999
Sex	2.421	1	2.421	0.522	.999
Residual	227.126	49	4.635		
Total	270.829	52	5.208		

TABLE A58: PROJECT TWO ANALYSIS OF VARIANCE ON MS4, YEAR THREE, (n=28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1.709	2	0.854	0.170	.999
Age	1.141	1	1.141	0.228	.999
AH4	0.096	1	0.096	0.019	.999
Main Effects	2.893	1	2.893	0.577	.999
Sex	2.893	1	2.893	0.577	.999
Residual	120.255	24	5.011		
Total	124.857	27	4.624		

TABLE A59: PROJECT TWO: ANALYSIS OF VARIANCE ON MS4, YEAR FOUR (n=51)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	20.340	2	10.170	2.206	.119
Age	0.129	1	0.129	0.028	.999
AH4	19.923	1	19.923	4.322	.041
Main Effects	19.760	1	19.760	4.287	.042
Sex	19.760	1	19.760	4.287	.042
Residual	216.645	47	4.609		
Total	256.745	50	5.135		

TABLE A60: PROJECT TWO: ANALYSIS OF VARIANCE ON MS4, YEAR FIVE (n=31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	10.968	2	5.484	1.193	.319
Age	8.327	1	8.327	1.811	.187
AH4	0.534	1	0.534	0.116	.999
Main Effects	2.740	1	2.740	0.596	.999
Sex	2.740	1	2.740	0.596	.999
Residual	124.162	27	4.599		
Total	137.871	30	4.596		

TABLE A61: PROJECT TWO: ANALYSIS OF VARIANCE ON MS5, TOTAL SAMPLE (n=190)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	131.379	2	65.690	13.053	.001
Age	52.231	1	52.231	10.379	.002
AH4	63.343	1	63.343	12.587	.001
Main Effects	95.145	1	95.145	18.906	.001
Sex	95.145	1	95.145	18.906	.001
Residual	936.032	186	5.032		
Total	1162.556	189	6.151		

TABLE A62: PROJECT TWO: ANALYSIS OF VARIANCE ON MS5, YEAR ONE, (n=27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	4.506	2	2.253	0.536	.999
Age	4.408	1	4.408	1.049	.318
AH4	2.041	1	2.041	0.486	.999
Main Effects	1.824	1	1.824	0.434	.999
Sex	1.824	1	1.824	0.434	.999
Residual	96.633	23	4.201		
Total	102.963	26	3.960		

TABLE A63: PROJECT TWO: ANALYSIS OF VARIANCE ON MS5, YEAR TWO (n=53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	61.144	2	30.572	7.409	.002
Age	1.920	1	1.920	0.465	.999
AH4	59.300	1	59.300	14.372	.001
Main Effects	10.149	1	10.149	2.460	.119
Sex	10.149	1	10.149	2.460	.119
Residual	202.177	49	4.126		
Total	273.471	52	5.259		

TABLE A64: PROJECT TWO: ANALYSIS OF VARIANCE ON MS5, YEAR THREE (n=28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	13.290	2	6.645	1.520	.238
Age	7.177	1	7.177	1.641	.210
AH4	1.746	1	1.746	0.399	.999
Main Effects	20.450	1	20.450	4.677	.039
Sex	20.450	1	20.450	4.677	.039
Residual	104.939	24	4.372		
Total	138.678	27	5.136		

TABLE A65: PROJECT TWO: ANALYSIS OF VARIANCE ON MS5, YEAR FOUR (n=51)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	29.541	2	14.770	2.268	.113
Age	7.258	1	7.258	1.114	.297
AH4	20.598	1	20.598	3.162	.078
Main Effects	52.664	1	52.664	8.085	.007
Sex	52.664	1	52.664	8.085	.007
Residual	306.144	47	6.514		
Total	388.350	50	7.767		

TABLE A66: PROJECT TWO: ANALYSIS OF VARIANCE ON MS5, YEAR FIVE (n=31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	16.531	2	8.266	2.016	.151
Age	13.604	1	13.604	3.319	.076
AH4	0.340	1	0.340	0.083	.999
Main Effects	55.491	1	55.491	13.536	.001
Sex	55.491	1	55.491	13.536	.001
Residual	110.687	27	4.100		
Total	182.709	30	6.090		

TABLE A67: PROJECT TWO: ANALYSIS OF VARIANCE ON TOTMS, TOTAL SAMPLE

(n = 190)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	7556.781	2	3778.391	33.548	.001
Age	1139.657	1	1139.657	10.119	.002
AH4	5691.895	1	5691.895	50.538	.001
Main Effects	1159.703	1	1159.703	10.297	.002
Sex	1159.706	1	1159.706	10.297	.002
Residual	20948.629	186	112.627		
Total	29665.113	189	156.958		

TABLE A68: PROJECT TWO: ANALYSIS OF VARIANCE ON TOTMS, YEAR 1 (n=27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	858.314	2	429.157	3.269	.055
Age	12.319	1	12.319	0.094	.999
AH4	493.424	1	493.424	3.758	.062
Main Effects	3.653	1	3.653	0.028	.999
Sex	3.653	1	3.653	0.028	.999
Residual	3019.658	23	131.289		
Total	3881.626	26	149.293		

TABLE A69: PROJECT TWO: ANALYSIS OF VARIANCE ON TOTMS, YEAR TWO

(n = 53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	3548.568	2	1774.284	15.975	.001
Age	157.176	1	157.176	1.415	.238
AH4	3478.820	1	3478.820	31.323	.001
Main Effects	75.040	1	75.040	0.676	.999
Sex	75.040	1	75.040	0.676	.999
Residual	5442.141	49	111.064		
Total	9065.750	52	174.341		

TABLE A70: PROJECT TWO: ANALYSIS OF VARIANCE ON TOTMS, YEAR THREE

(n =28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1225.243	2	612.622	7.579	.003
Age	472.677	1	472.677	5.848	.022
AH4	309.045	1	309.045	3.823	.060
Main Effects	601.762	1	601.762	7.445	.011
Sex	601.762	1	601.762	7.445	.011
Residual	1939.956	24	80.831		
Total	3766.961	27	139.517		

TABLE A71: PROJECT TWO: ANALYSIS OF VARIANCE ON TOTMS, YEAR FOUR (n=51)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1192.500	2	596.250	6.739	.003
Age	73.600	1	73.600	0.832	.999
AH4	1078.003	1	1078.003	12.184	.001
Main Effects	1209.171	1	1209.171	13.667	.001
Sex	1209.171	1	1209.171	13.667	.001
Residual	4158.316	47	88.475		
Total	6559.988	50	131.200		

TABLE A72: PROJECT TWO: ANALYSIS OF VARIANCE ON TOTMS, YEAR 5 (n=31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	442.973	2	221.486	2.498	.099
Age	14.086	1	14.086	0.159	.999
AH4	437.526	1	437.526	4.935	.033
Main Effects	832.642	1	832.642	9.392	.005
Sex	832.642	1	832.642	9.392	.005
Residual	2393.736	27	88.657		
Total	3669.351	30	122.312		

TABLE A73: PROJECT TWO: ANALYSIS OF VARIANCE ON MAP2, TOTAL SAMPLE

(n = 190)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	372.492	2	186.246	20.760	.001
Age	56.771	1	56.771	6.328	.012
AH4	279.852	1	279.852	31.194	.001
Main Effects	44.280	1	44.280	4.936	.026
Sex	44.280	1	44.280	4.936	.026
Residual	1668.679	186	8.971		
Total	2085.452	189	11.034		

TABLE A74: PROJECT TWO: ANALYSIS OF VARIANCE ON MAP2, YEAR ONE

(n = 27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	51.563	2	25.781	2.618	.093
Age	20.218	1	20.218	2.053	.162
AH4	51.178	1	51.178	5.197	.031
Main Effects	4.662	1	4.662	0.473	.999
Sex	4.662	1	4.662	0.473	.999
Residual	226.515	23	9.848		
Total	282.740	26	10.875		

TABLE A75: PROJECT TWO: ANALYSIS OF VARIANCE ON MAP2, YEAR TWO

(n = 53)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	79.997	2	39.998	4.362	.018
Age	0.100	1	0.100	0.011	.999
AH4	72.206	1	72.206	7.875	.007
Main Effects	6.805	1	6.805	0.742	.999
Sex	6.805	1	6.805	0.742	.999
Residual	449.308	49	9.170		
Total	536.110	52	10.310		

TABLE A76: PROJECT TWO: ANALYSIS OF VARIANCE ON MAP2, YEAR THREE

(n = 28)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	39.304	2	19.652	2.043	.150
Age	1.907	1	1.907	0.198	.999
AH4	26.899	1	26.899	2.796	.104
Main Effects	4.527	1	4.527	0.471	.999
Sex	4.527	1	4.527	0.471	.999
Residual	230.883	24	9.620		
Total	274.714	27	10.175		

TABLE A77: PROJECT TWO: ANALYSIS OF VARIANCE ON MAP2, YEAR FOUR (n=51)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	54.102	2	27.051	2.396	.100
Age	4.733	1	4.733	0.419	.999
AH4	51.138	1	51,138	4.530	.037
Main Effects	39.993	1	39.993	3.543	.063
Sex	39.993	1	39.993	3.543	.063
Residual	530.527	47	11.288		
Total	624.623	50	12.492		

TABLE A78: PROJECT TWO: ANALYSIS OF VARIANCE ON MAP2, YEAR FIVE (n=31)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	34.004	2	17.002	3.438	.046
Age	8.084	1	8.084	1.635	.210
AH4	32.400	1	32.400	6.551	.016
Main Effects	25.820	1	25.820	5.221	.029
Sex	25.820	1	25.820	5.221	.029
Residual	133.530	27	4.946		
Total	193.355	30	6.445		

TABLE A79: PROJECT TWO: ANALYSIS OF VARIANCE ON COMPLACE 2, TOTAL SAMPLE

(n = 190)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	4.023	2	2.011	0.562	.999
Age	0.441	1	0.441	0.123	.999
AH4	3.234	1	3.234	0.904	.999
Main Effects	53.255	1	53.255	14.886	.001
Sex	53.255	1	53.255	14.886	.001
Residual	665.420	186	3.578		
Total	722.698	189	3.824		

TABLE A80: PROJECT TWO: ANALYSIS OF VARIANCE ON COMPLACE2, YEAR ONE

(n = 27)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	26.451	2	13.225	2.455	.106
Age	25.103	1	25.103	4.660	.040
AH4	14.082	1	14.082	2.614	.116
Main Effects	3.654	1	3.654	0.678	.999
Sex	3.654	1	3.654	0.678	.999
Residual	123.895	23	5.387		
Total	154.000	26	5.923		

TABLE A81: PROJECT TWO: ANALYSIS OF VARIANCE ON COMPLACE 2, YEAR TWO

(n = 53)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	0.358	2	0.179	0.061	.999
Age	0.301	1	0.301	0.103	.999
AH4	0.001	1	0.001	0.000	.999
Main Effects	48.851	1	48.851	16.684	.001
Sex	48.851	1	48.851	16.684	.001
Residual	143.471	49	2.928		
Total	192.679	52	3.705		

TABLE A82: PROJECT TWO: ANALYSIS OF VARIANCE ON COMPLACE 2, YEAR THREE

(n= 28)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	6.817	2	3.409	1.275	.298
Age	6.431	1	6.431	2.405	.130
AH4	0.122	1	0.122	0.045	.999
Main Effects	19.715	1	19.715	7.372	.012
Sex	19.715	1	19.715	7.372	.012
Residual	64.182	24	2.674		
Total	90.714	27	3.360		

TABLE A83: PROJECT TWO: ANALYSIS OF VARIANCE ON COMPLACE 2, YEAR FOUR

(n = 51)

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	3.913	2	1.957	0.510	.999
Age	1.465	1	1.465	0.382	.999
AH4	2.686	1	2.686	0.700	.999
Main Effects	6.663	1	6.663	1.736	.191
Sex	6.663	1	6.663	1.736	.191
Residual	180.404	47	3.838		
Total	190.980	50	3.820		

TABLE A84: PROJECT TWO: ANALYSIS OF VARIANCE ON COMPLACE 2, YEAR FIVE

(n = 31)

SOURCE OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF. OF F
Covariates	1.763	2	0.882	0.314	.999
Age	1.586	1	1.586	0.564	.999
AH4	0.002	1	0.002	0.001	.999
Main Effects	0.353	1	0.353	0.126	.999
Sex	0.353	1	0.353	0.126	.999
Residual	75.884	27	2.811		
Total	78.000	30	2.600		

APPENDIX VIII

TESTS AND PHOTOGRAPHS

GUILFORD - ZIMMERMAN TESTS

(1) SPATIAL ORIENTATION

(2) SPATIAL VISUALIZATION

(pages 537 - 552)

THE GUILFORD-ZIMMERMAN APTITUDE SURVEY

Part V Spatial Orientation

Form A

Name________________________________ Date________________ Score________

Nearest age: 10 15 20 25 30 35 45 55 65 75 Sex: M F

Years of school completed: 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Instructions.—This is a test of your ability to see changes in direction and position. In each item you are to note how the position of the boat has changed in the second picture from its original position in the first picture.

Here is a sample item.

These are the five possible answers to the item.

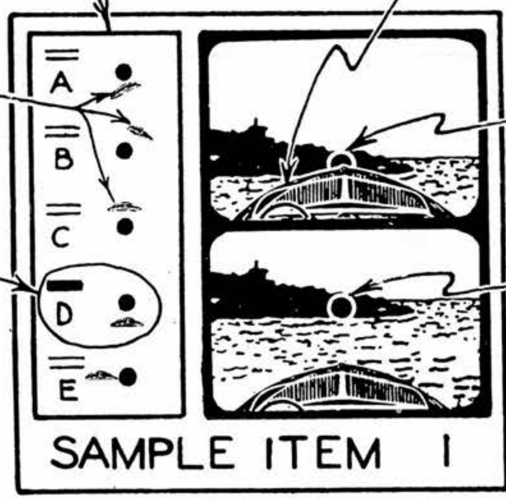
This is the prow (front end) of a motor boat in which ***you*** are riding.

These are tiny pictures of the boat's prow.

This is the aiming point. It is the exact spot you would see on land if you sighted right over the point of the prow.

This is the correct answer. It shows that the prow of the boat **has dropped below the aiming point.**

This is the same aiming point shown above. Note that the prow of the motor boat has dropped below it.



(If the prow had risen, instead of dropped, the correct answer would have been C, instead of D.)

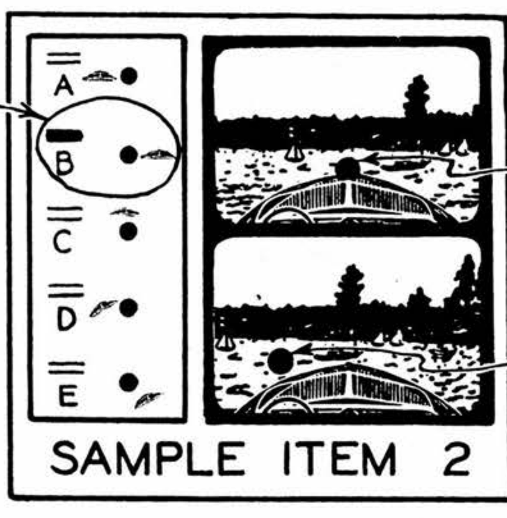
Other items in the test are very similar to SAMPLE ITEM 1. To work each item: ***First,*** look at the top picture. See where the motor boat is headed. ***Second,*** look at the bottom picture and note the CHANGE in the boat's heading. ***Third,*** mark the answer that shows the same change.

Try Sample Item 2.

is also shows that the prow of e boat is to the right of the ming point. So, it is the cor-t answer.

This is the aiming point.

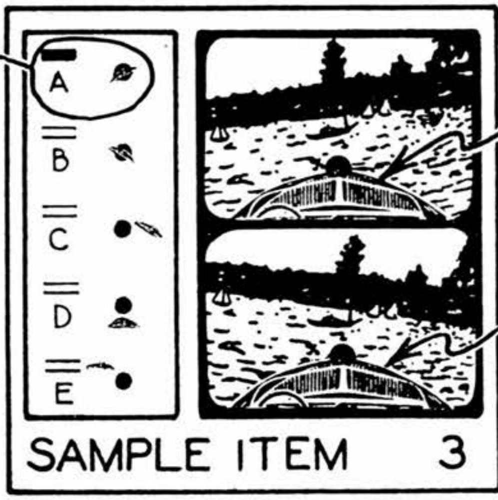
This is the same aiming point. The motor boat is now headed to the right of it.



(If the boat had turned to the left, instead of to the right, the correct answer would have been A.)

Now try Sample Item 3.

This is the correct answer. It shows that the motor boat changed its slant to the left, but that it is still heading toward the aiming point.



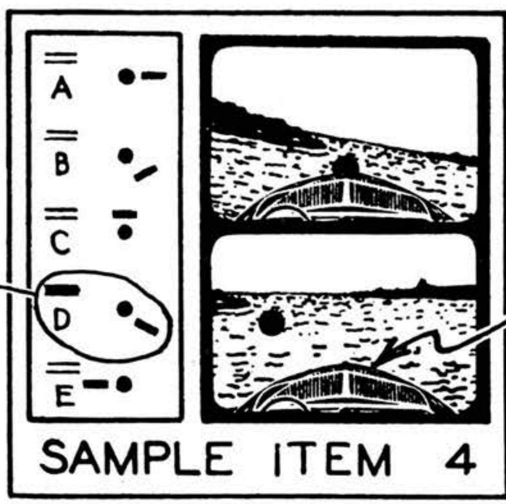
Here the motor boat is slante slightly to the right. (Note th the horizon appears to slant the opposite direction.)

Here the boat has changed i slant toward the left. (See e planation below.)

Imagine that these pictures were taken with a motion picture camera. The camera is fastened rigidly to the boat so that it bobs up and down, turns and slants with the boat. Thus, when the boat tips or slants to the left (as in the lower picture in SAMPLE ITEM 3), the scene through the camera view finder looks slanted like this.

Look at Sample Item 4.

D is the correct answer. It shows that the boat (from now on only a bar will be shown in the answer in place of the tiny picture of the boat's prow) changed its heading both downward and to the right; also that it changed its slant toward the right. (In the top picture the boat was slanting left. To become level, the boat slanted back toward the right.



The prow of the boat h moved downward and towa the right. Also it has change its slant toward the right. was slanted left in the top pi ture, and it became level. T become level, it had to sla back toward the right.)

Now Do Practice Items 5, 6, and 7. Record Your Answers.

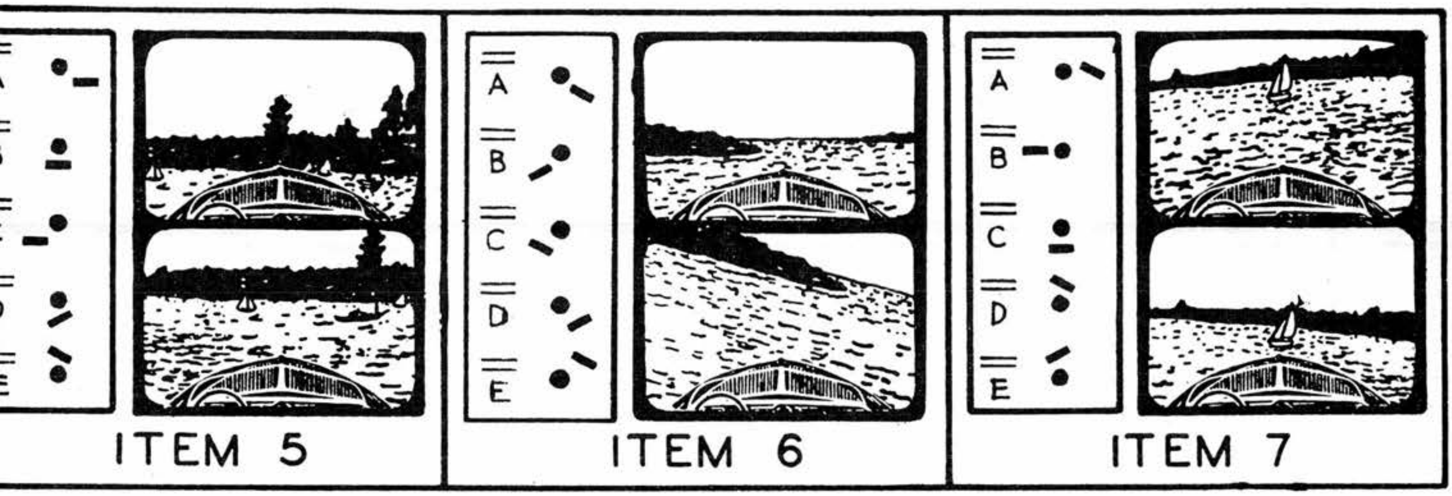
The aiming point is not marked in the test items. You must see the change in the boat's position without the id of the dots.

To Review:

First — Look at the top picture. See where the motor boat is headed.

Second — Look at the bottom picture. Note the change in the boat's heading.

Third — Mark the answer that shows the same change (in reference to the aiming point before the change).



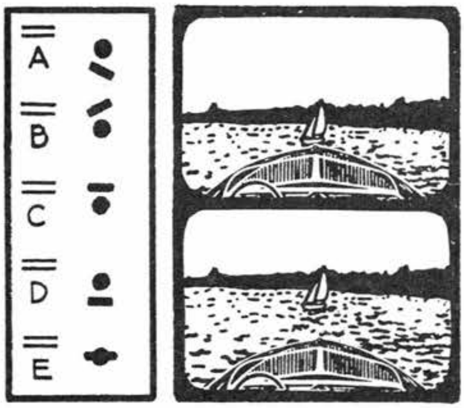
C is the correct answer. The prow ppears to have moved to the left nd downward. It has not hanged its slant.

B is the correct answer. The prow appears to have moved to the left and downward. Also, it has changed its slant to the left.

E is the correct answer. The prow appears to have moved upward, and to have tipped left. It has not turned.

If you have any questions, ask them now.

At the signal from the examiner, not before, turn the page and begin working on the test. Work rapidly. If you are not sure about any item, you may guess, but avoid wild guessing. Your score will be the number of answers correct minus a small fraction of the number wrong. You will have **ten minutes** to work on the test. Wait for the signal to begin.



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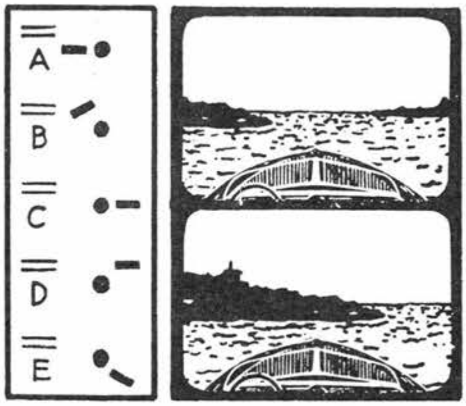

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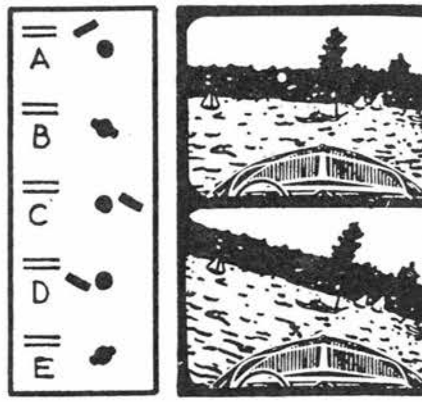

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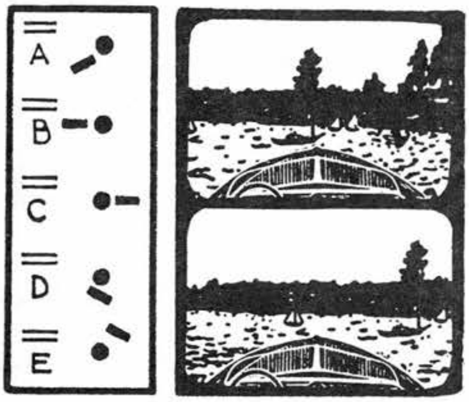

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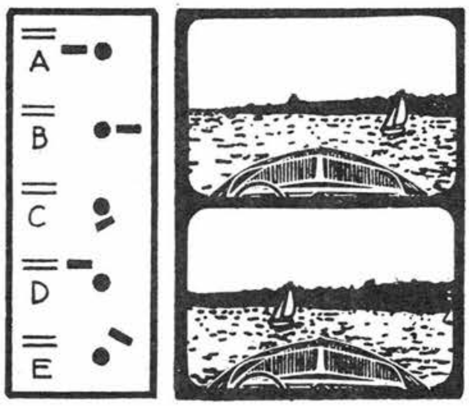

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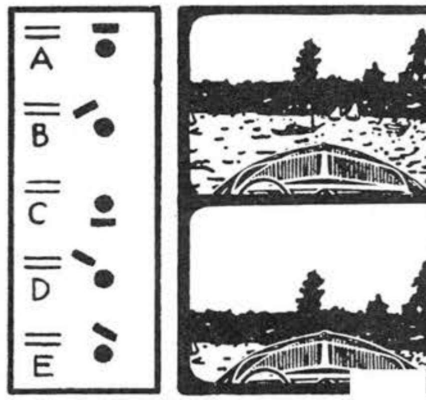

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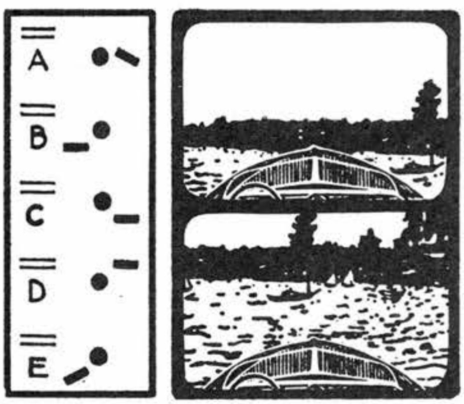

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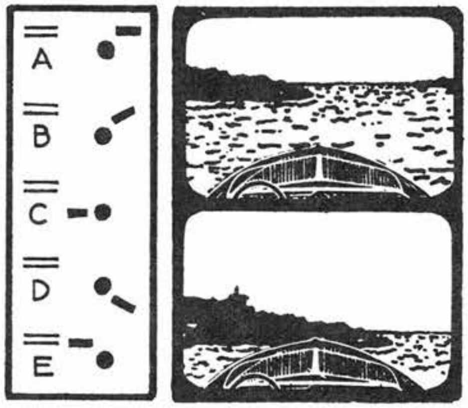

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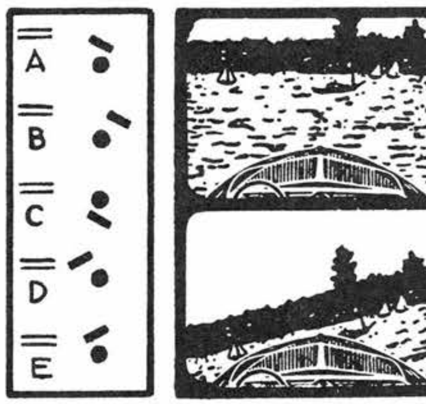

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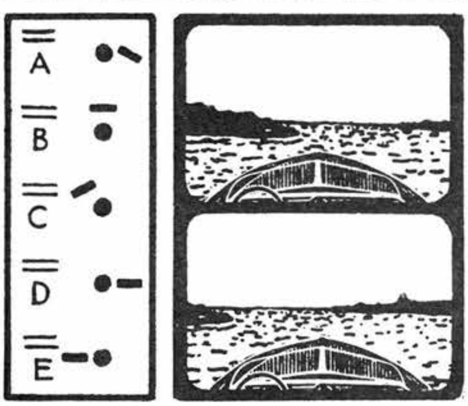

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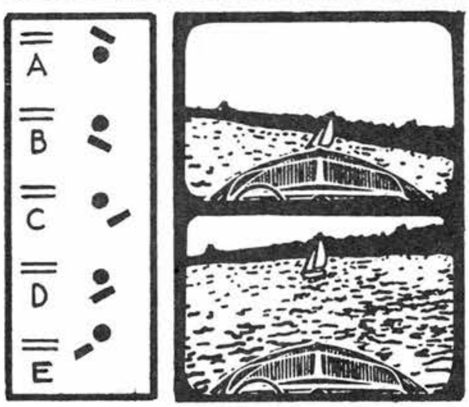

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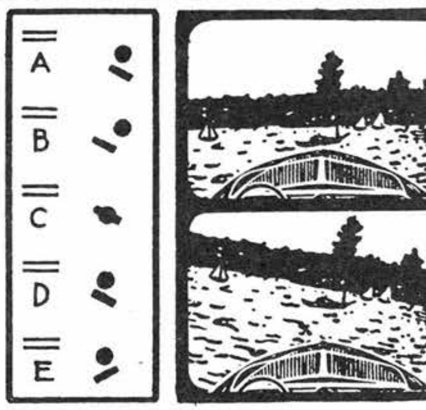

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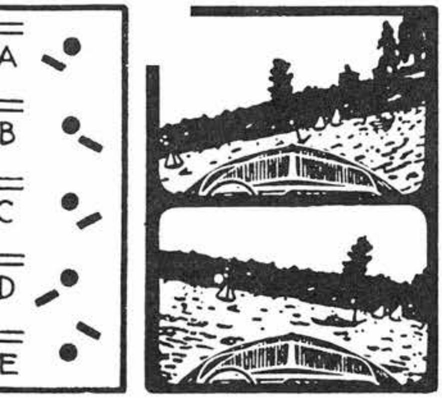

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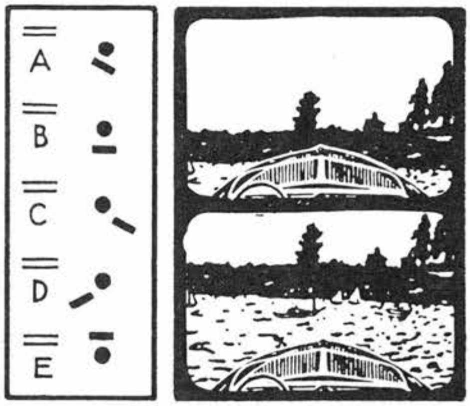

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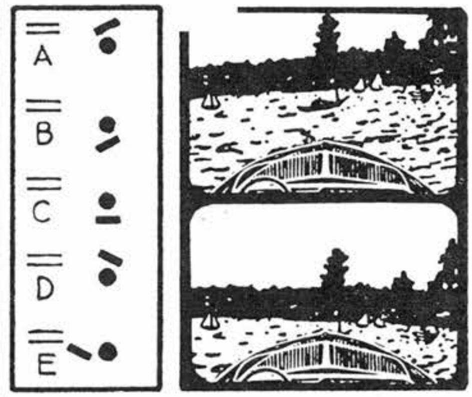

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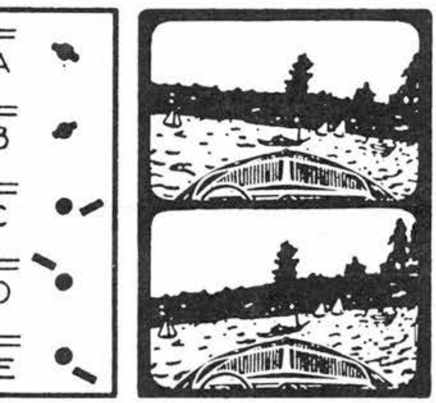

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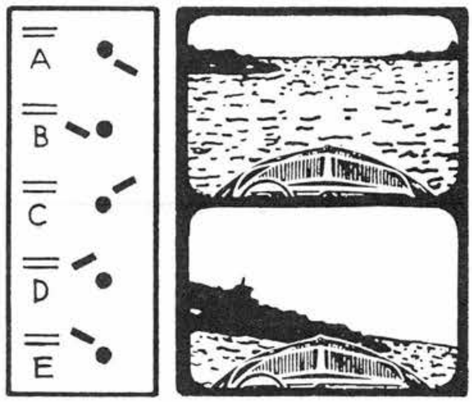

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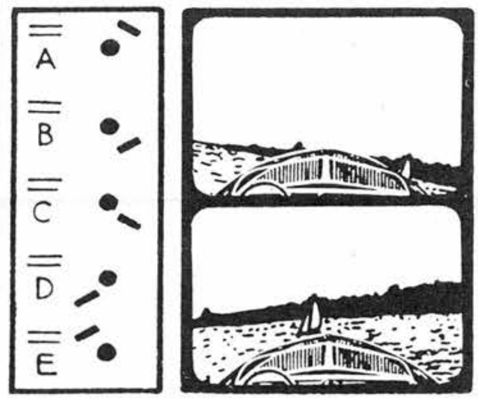

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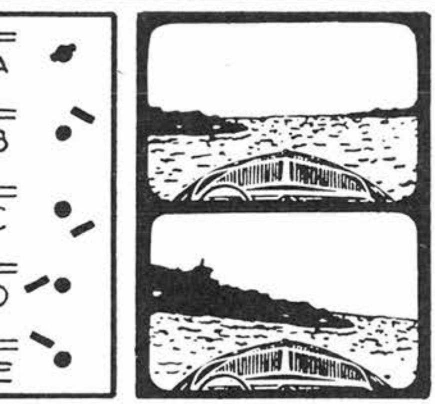

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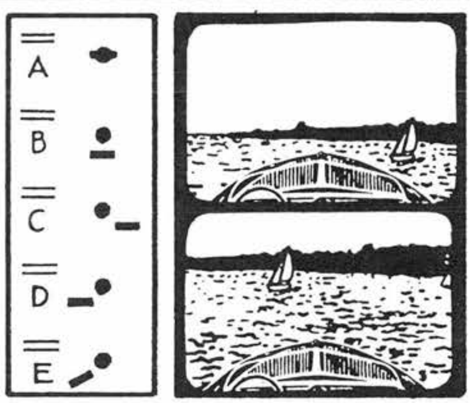

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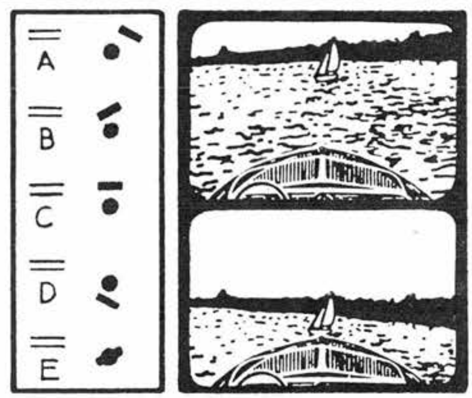

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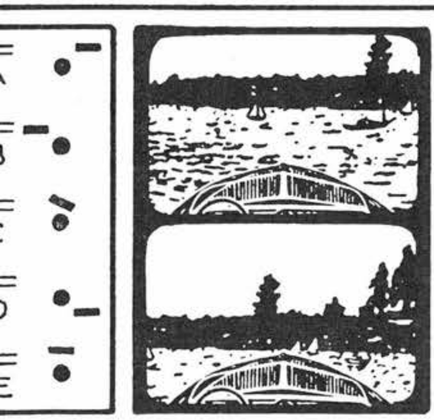

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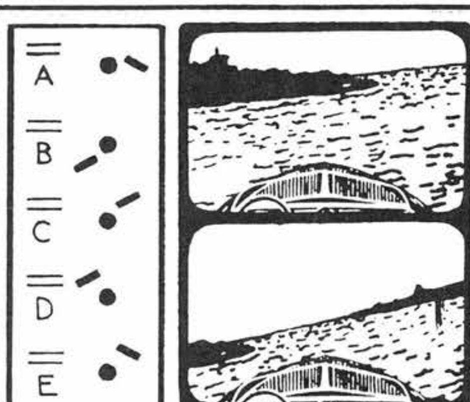

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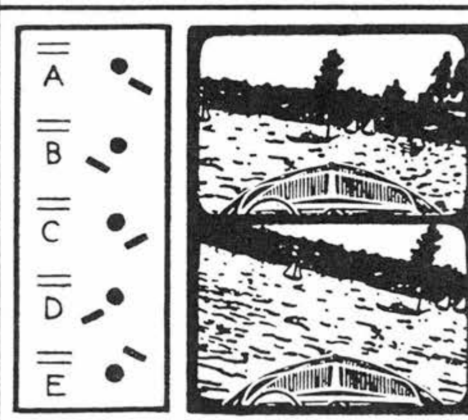

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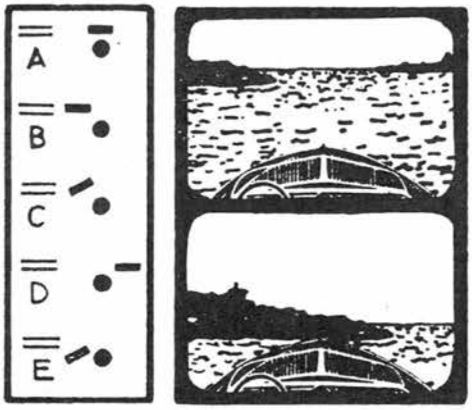

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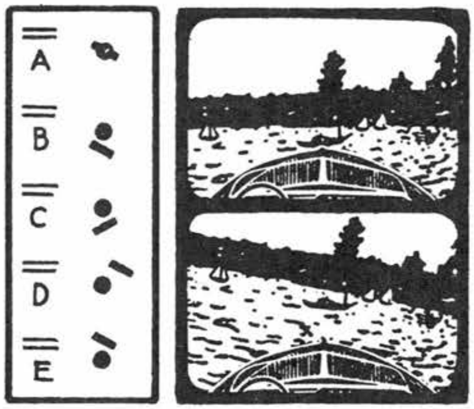

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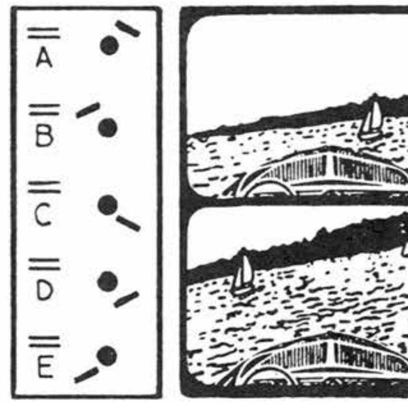

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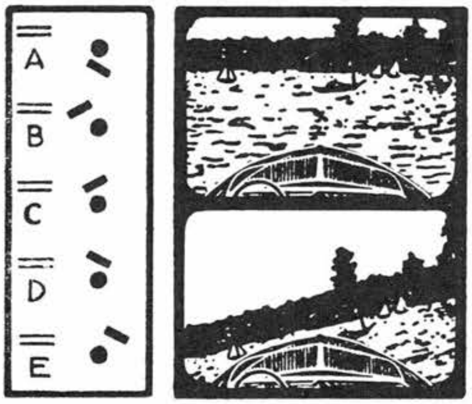

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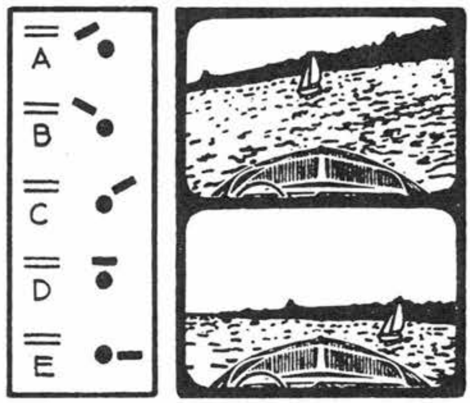

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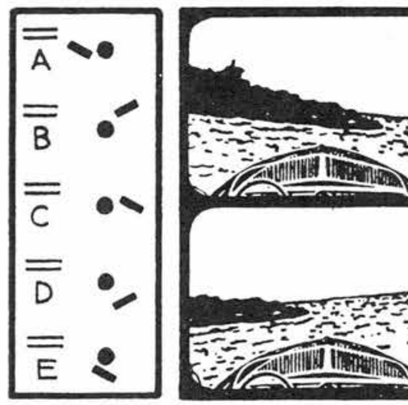

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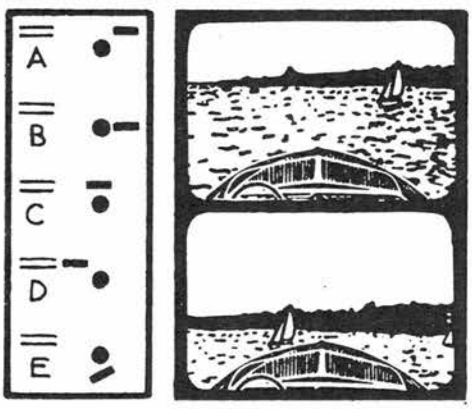

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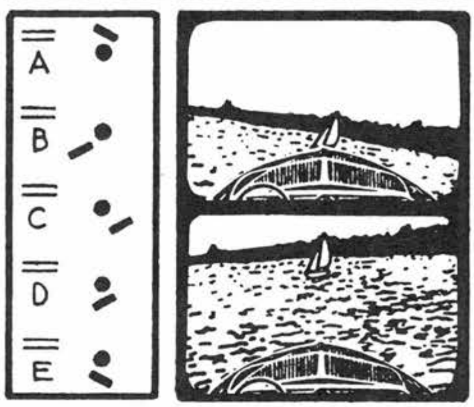

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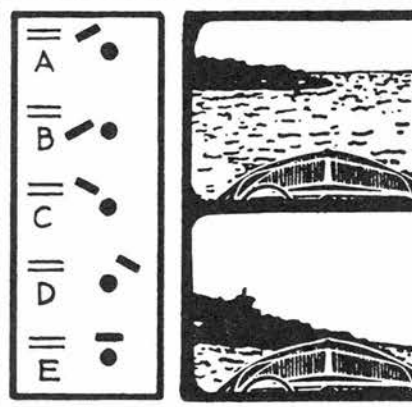

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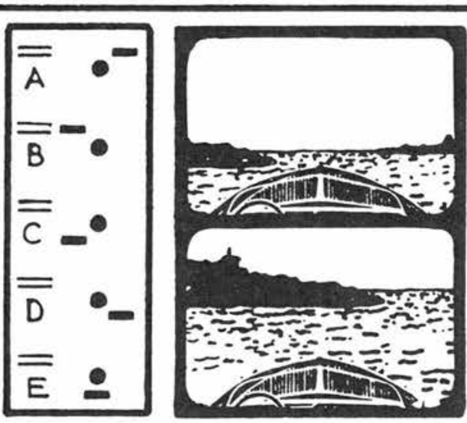

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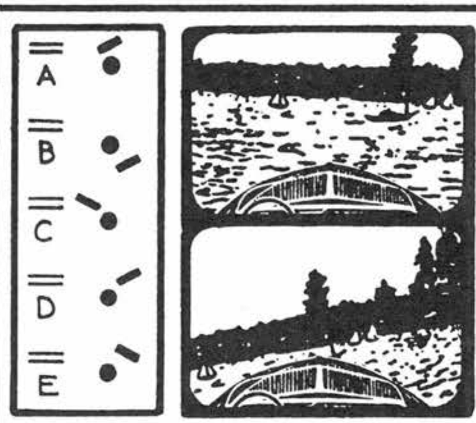

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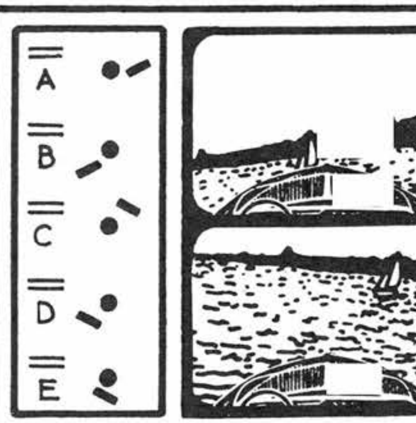

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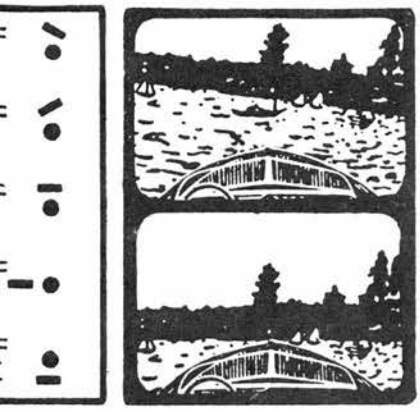

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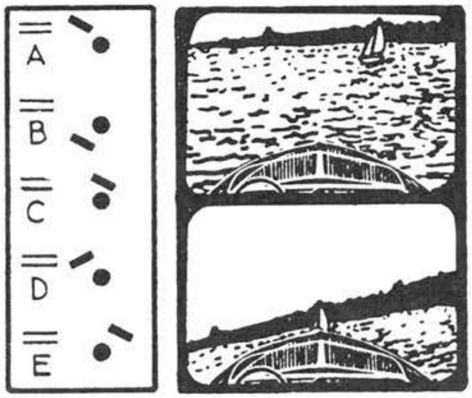

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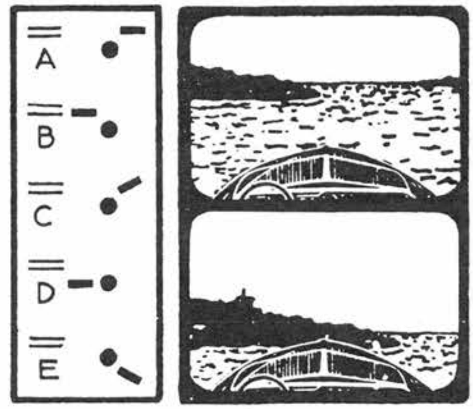

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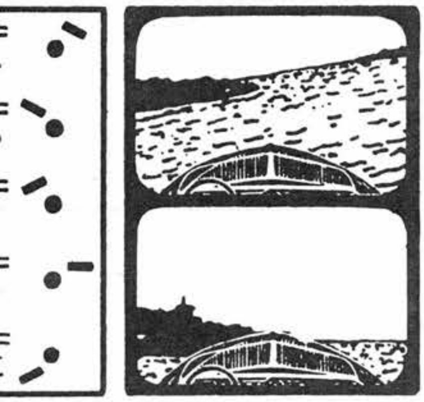

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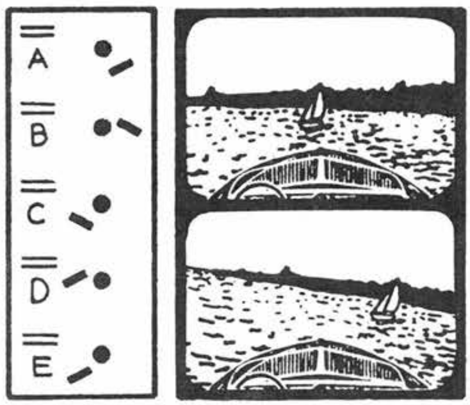

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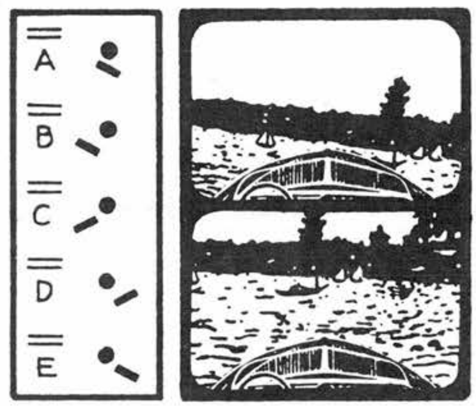

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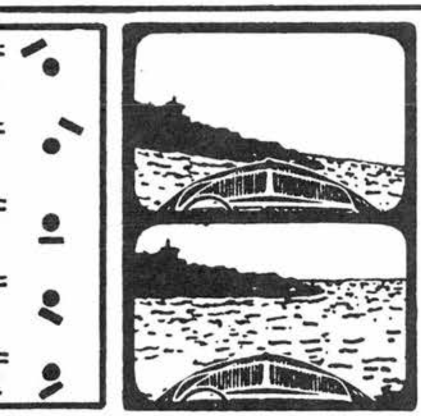

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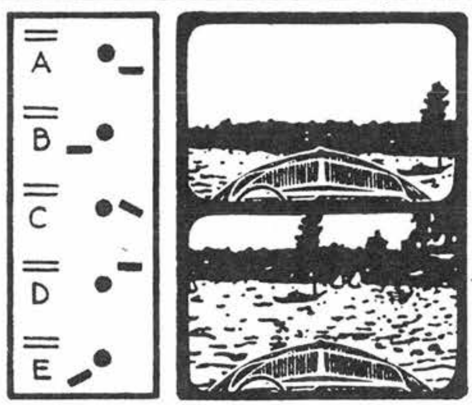

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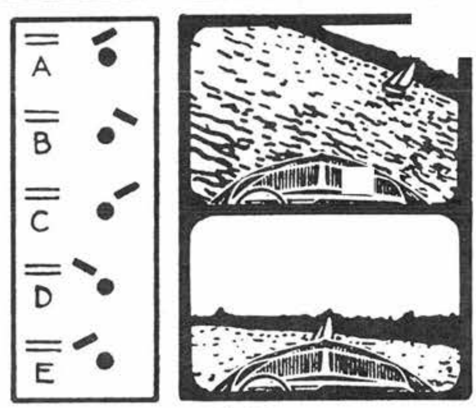

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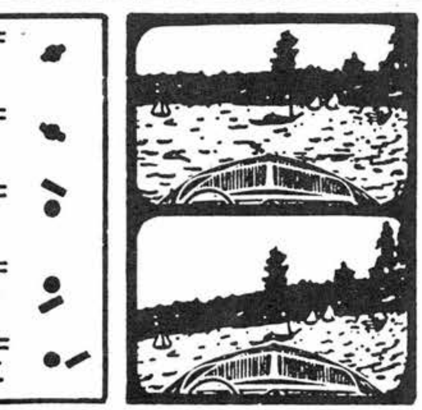

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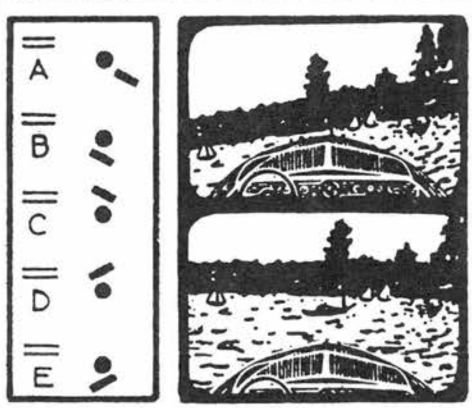

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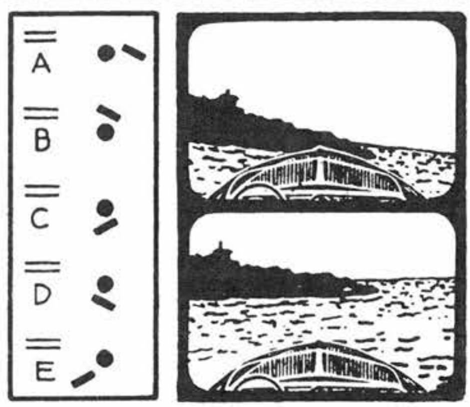

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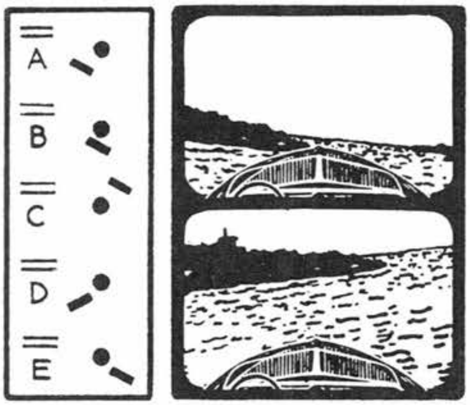

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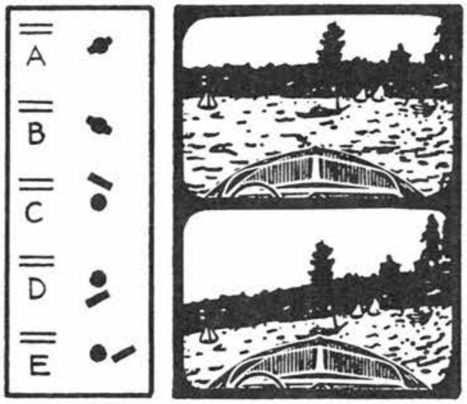

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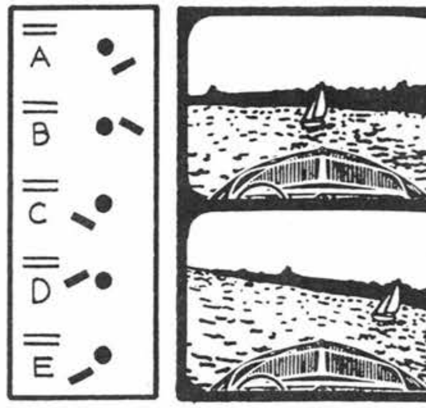

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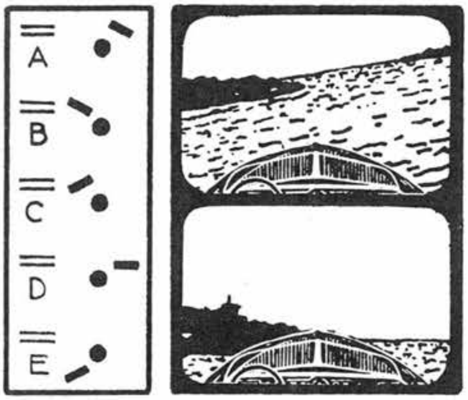

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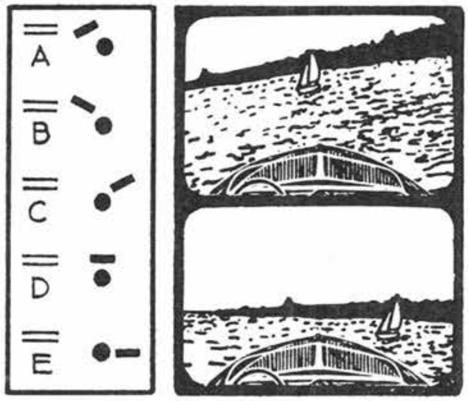

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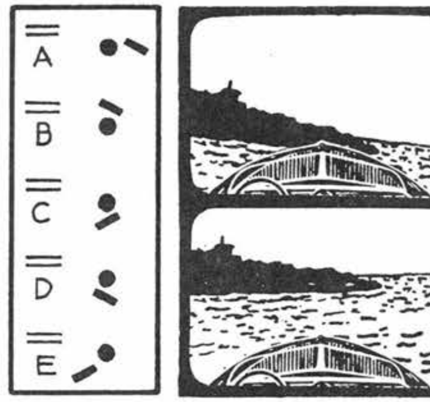

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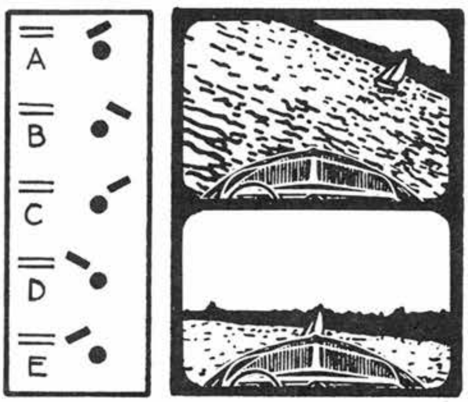

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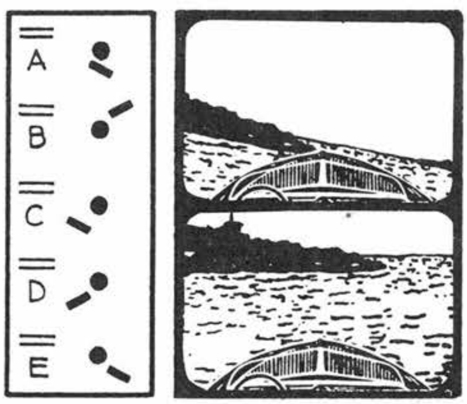

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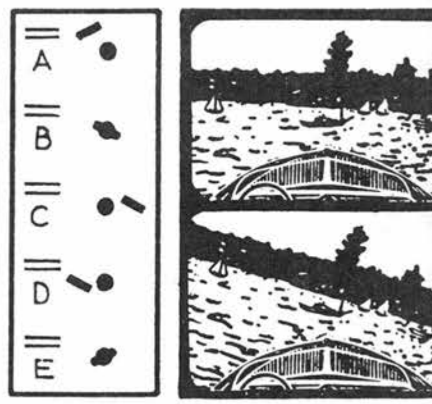

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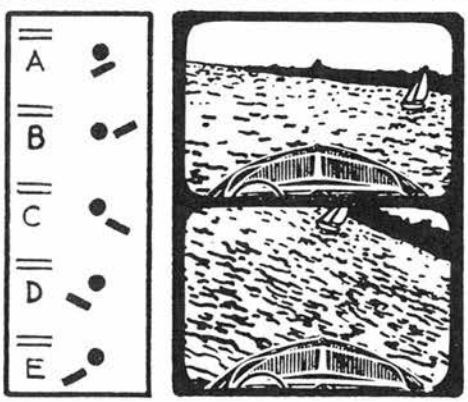

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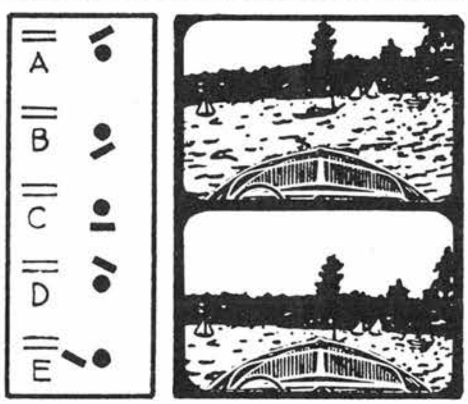

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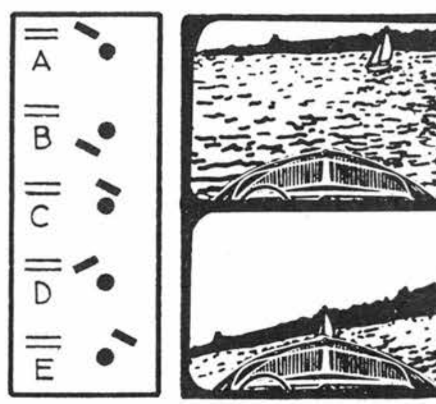


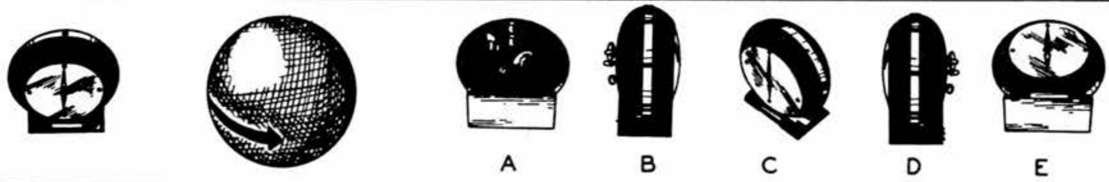
67

THE GUILFORD-ZIMMERMAN APTITUDE SURVEY

Part VI Spatial Visualization

Form B

I

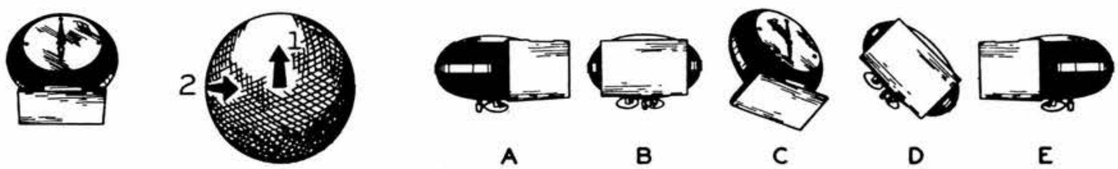


The first picture at the left shows a clock. Next to it is a sphere with an arrow marked on it. The arrow shows how the clock is to be moved. This move is illustrated (in two steps) in the picture below. When the clock is moved the one-quarter turn shown by the arrow, it is then in position B. B is therefore the correct answer. You would record this by blackening the answer space right below B on your answer sheet. (But do not record answers to sample items.)

Original position

Position after the move has been completed.

II



Two movements of the clock are called for by the two arrows on the sphere. Move number 1 must be visualized first. Move number 2 must then be started from the clock's position after the first move. In item II, each arrow shows one-eighth of a turn. The two moves, if visualized correctly, would place the clock in position A. The pictures below illustrate, in two steps, how the two moves should be visualized, one following the other.

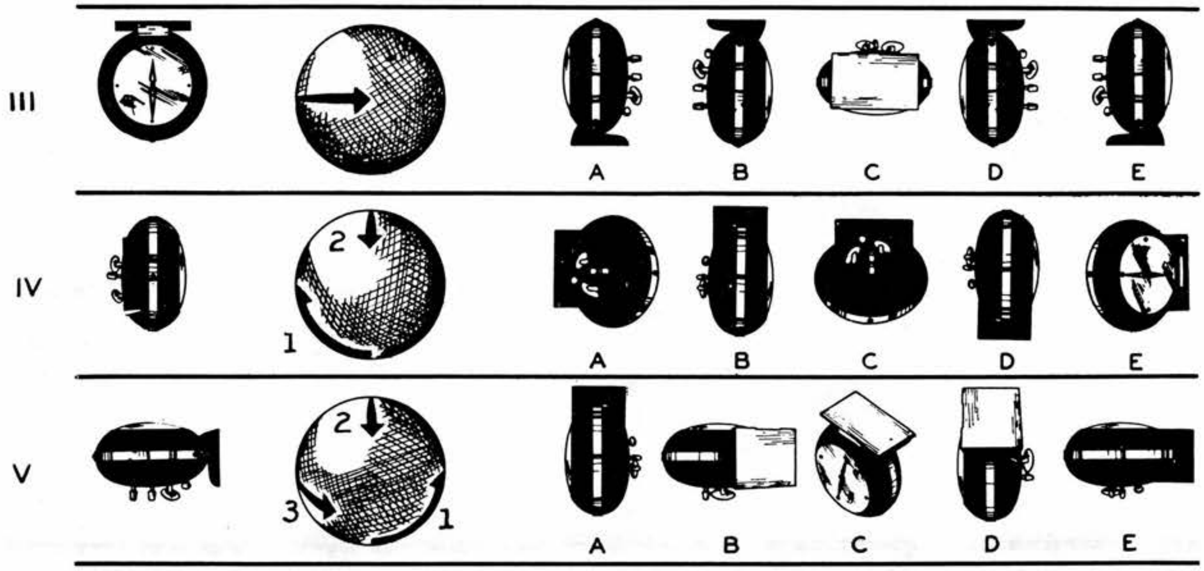
Original Position

Position after move number 1

Position after move number 2

In some of the items, three moves will be called for. Remember that each move, after the first, must be started from the clock's position after the move just before has been completed.

Now try sample items III, IV, and V:



The correct answers are: III, B; IV, C; V, C. If you did not get these answers, look over the items again to see where you made your mistakes.

If you have any questions, ask them **NOW**.

You will have 10 minutes to work on this test. Do not spend too much time on any one item. If you finish before time is called, you may go back and check your work.

If you are not sure about the answer to any item, you may guess, but avoid wild guessing. Your score will be the number of correct answers minus a fraction of the number wrong.

WAIT FOR THE SIGNAL TO BEGIN.

DO NOT WRITE IN THIS BOOKLET

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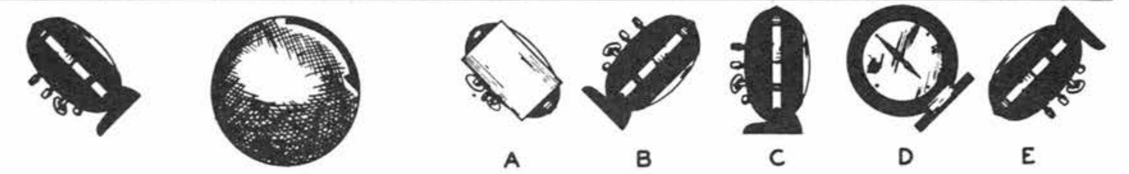

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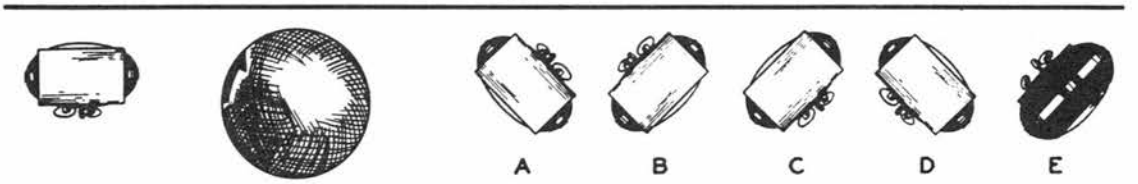

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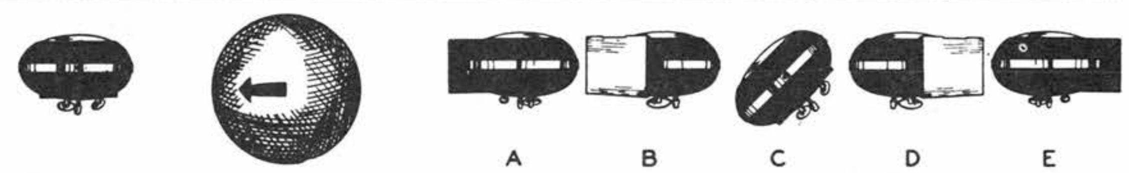

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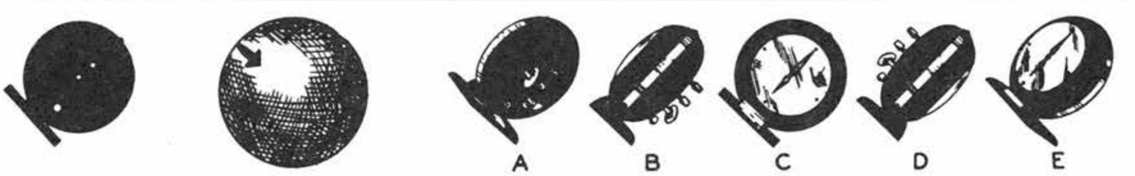

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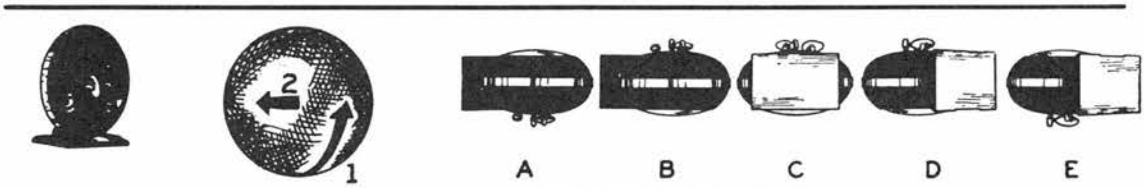

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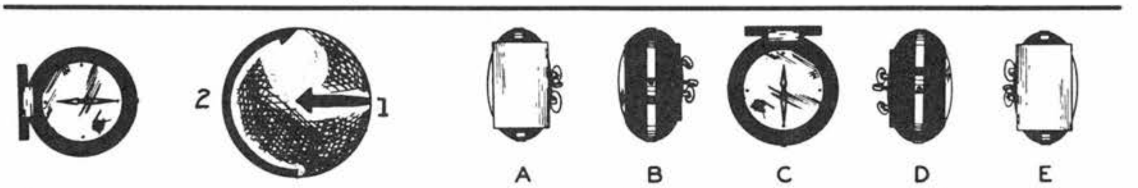

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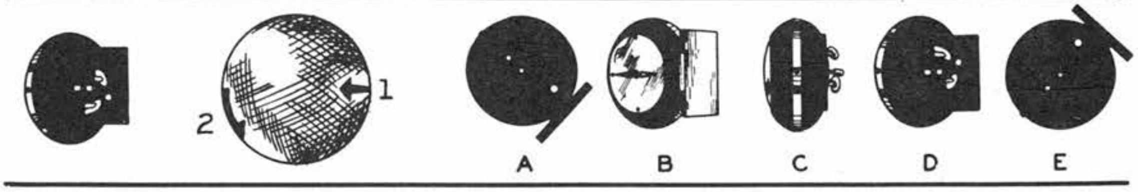

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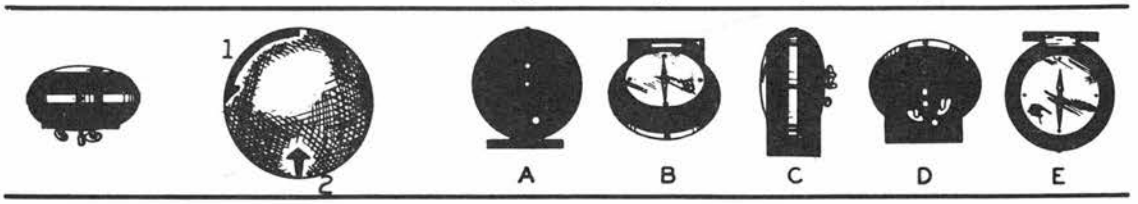

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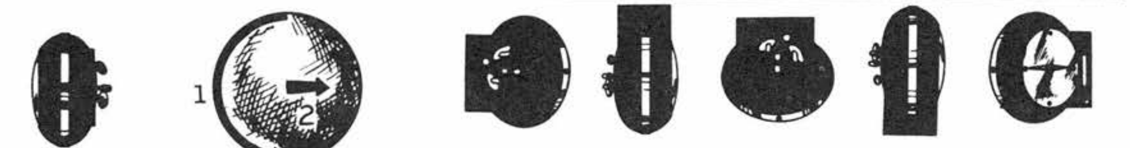
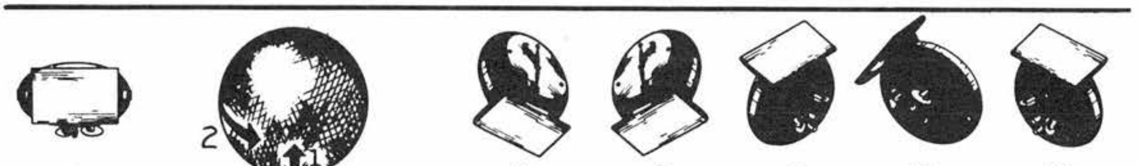


A B C D E

12



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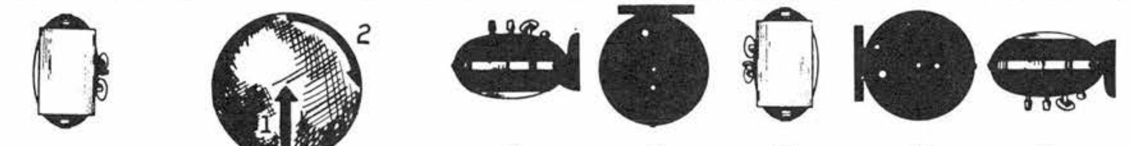

A B C D E

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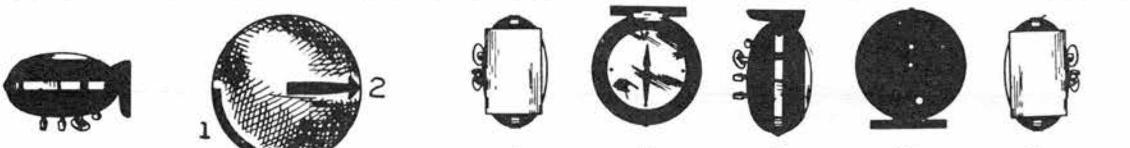

A B C D E

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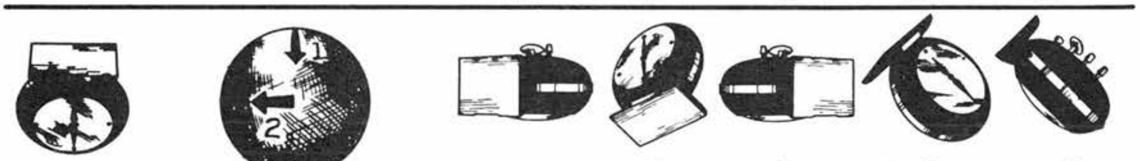

A B C D E

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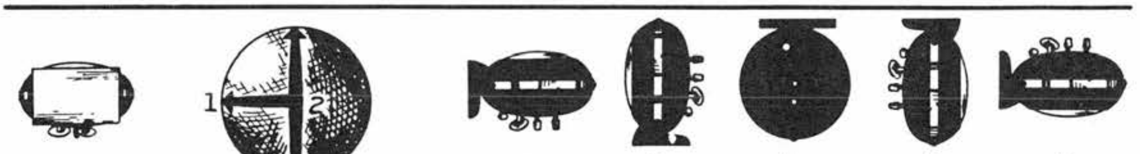

A B C D E

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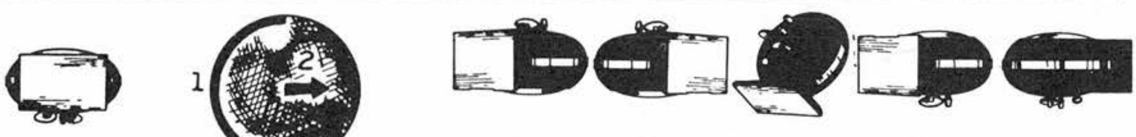

A B C D E

18

A B C D E

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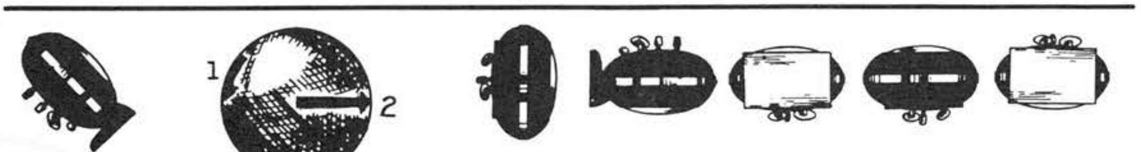

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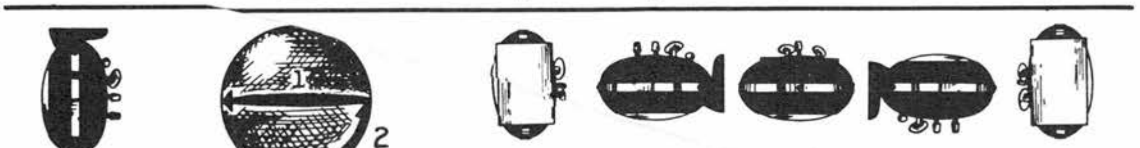

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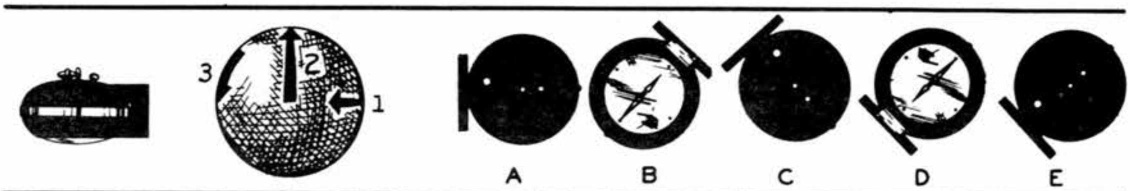

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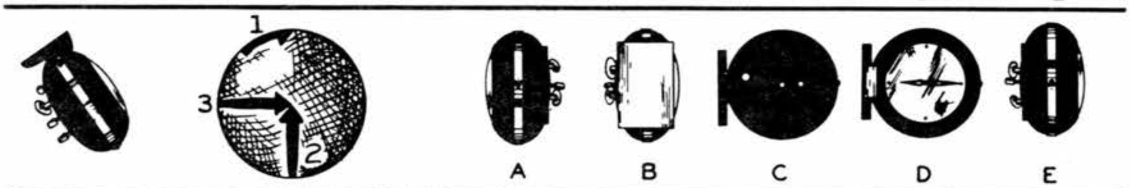

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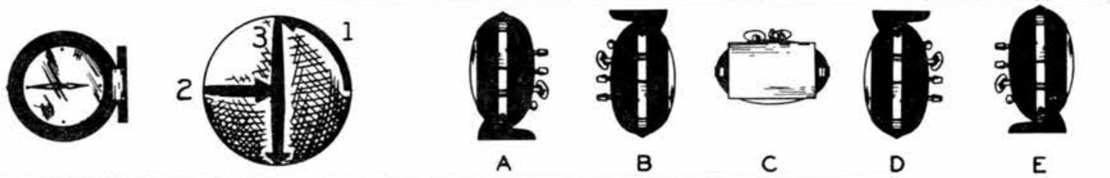

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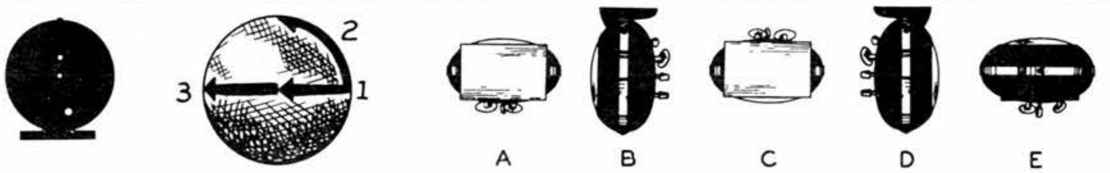

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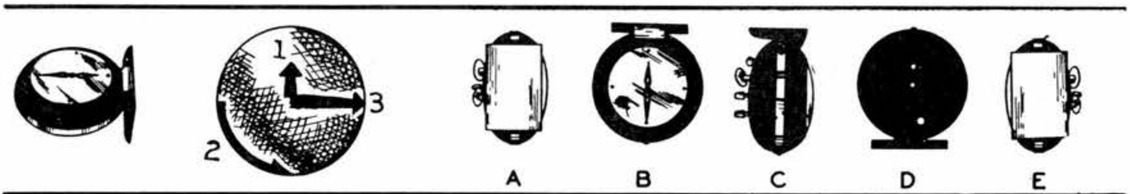

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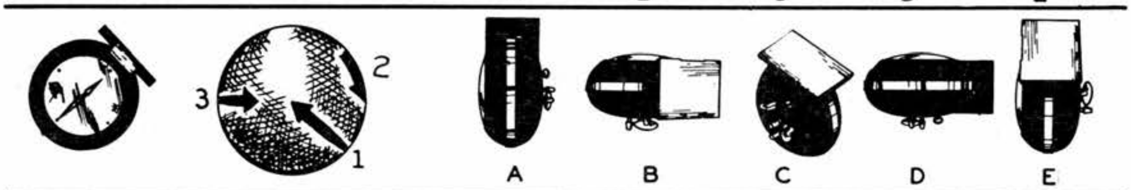

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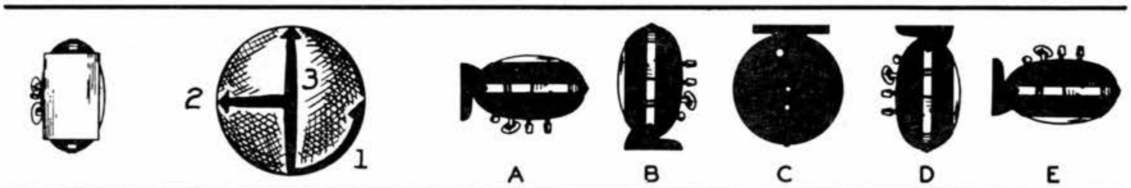

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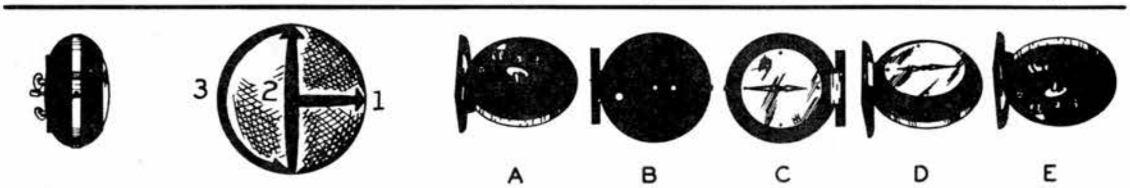

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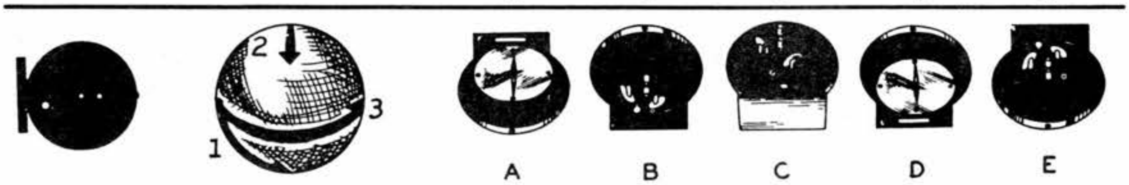

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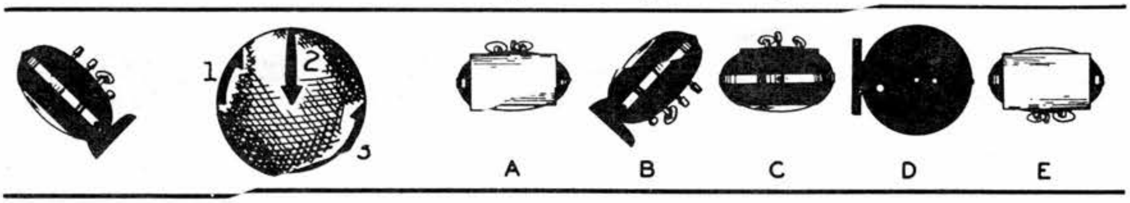

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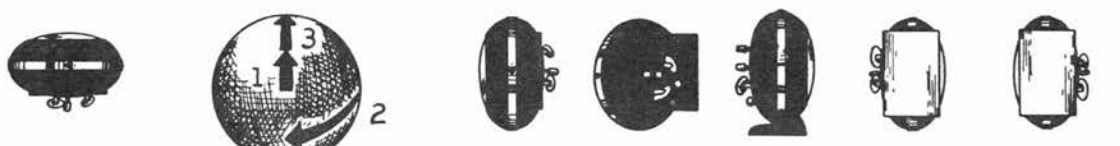
A B C D E

32 

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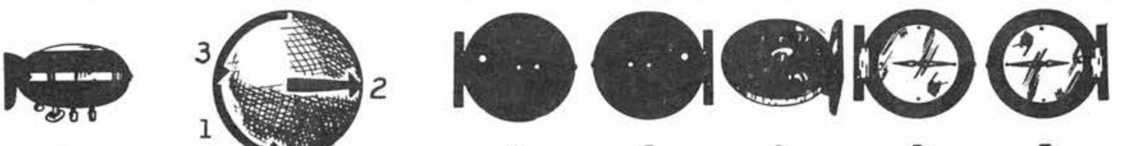
33 

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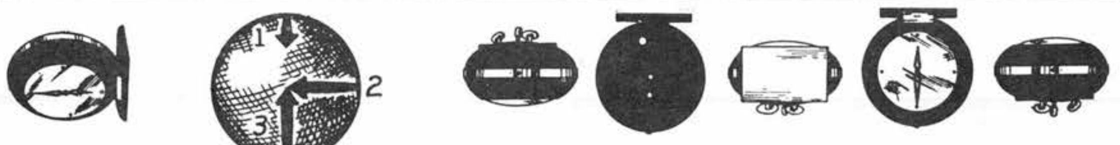
34 

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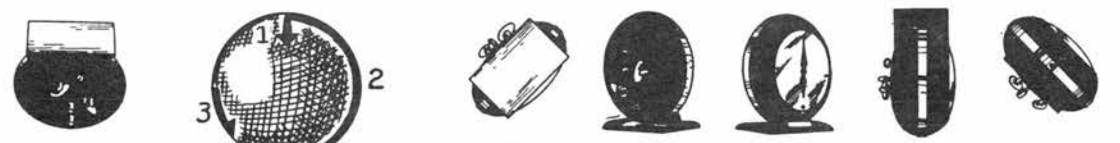
35 

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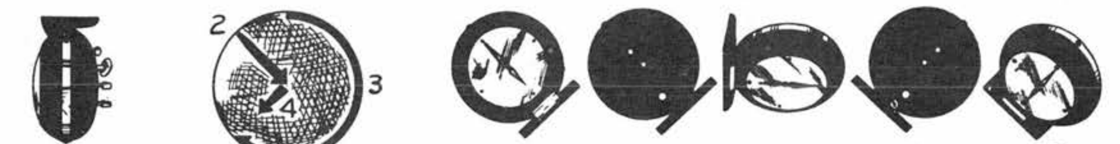
36 

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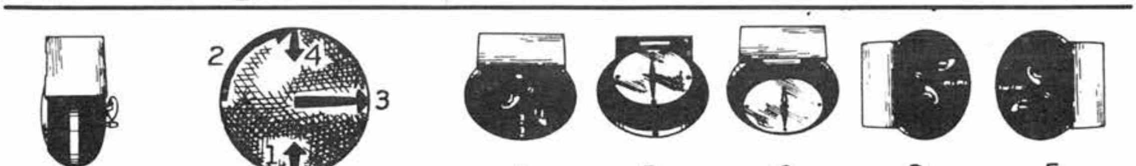
37 

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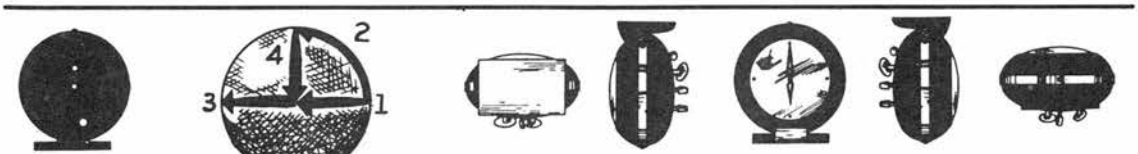
38 

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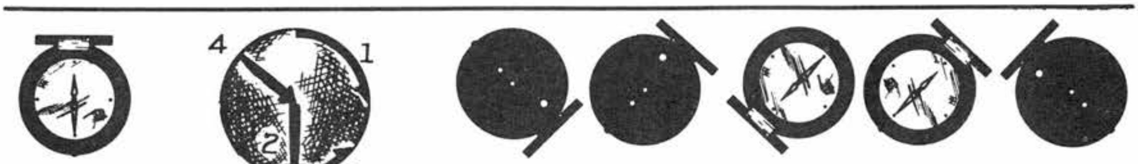
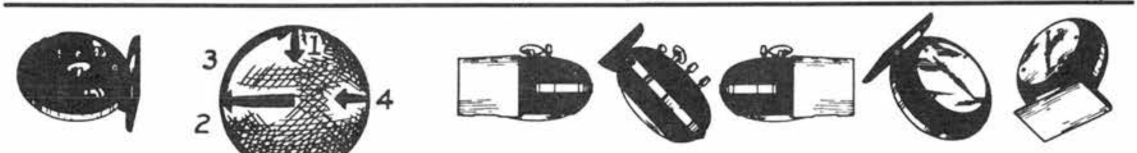
39 

A B C D E

40 

A B C D E

DIFFERENTIAL APTITUDE SPACE

RELATIONS TEST (DAT)

(pages 553 - 564)

THE PSYCHOLOGICAL CORPORATION

Ψ

DIFFERENTIAL APTITUDE TESTS

George K. Bennett
Harold G. Seashore
Alexander G. Wesman

SPACE RELATIONS

FORM A

Do not open this booklet until you are told to do so.

On your SEPARATE ANSWER SHEET, print your name, address, and other requested information in the proper spaces.

In the space after **Form**, print an **A.**

Then wait for further instructions.

DO NOT MAKE ANY MARKS IN THIS BOOKLET

The test contained in this booklet has been designed for use with answer forms published or authorized by The Psychological Corporation. If other answer forms are used, The Psychological Corporation takes no responsibility for the meaningfulness of scores.

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66-391TB

Do not make any marks in this booklet

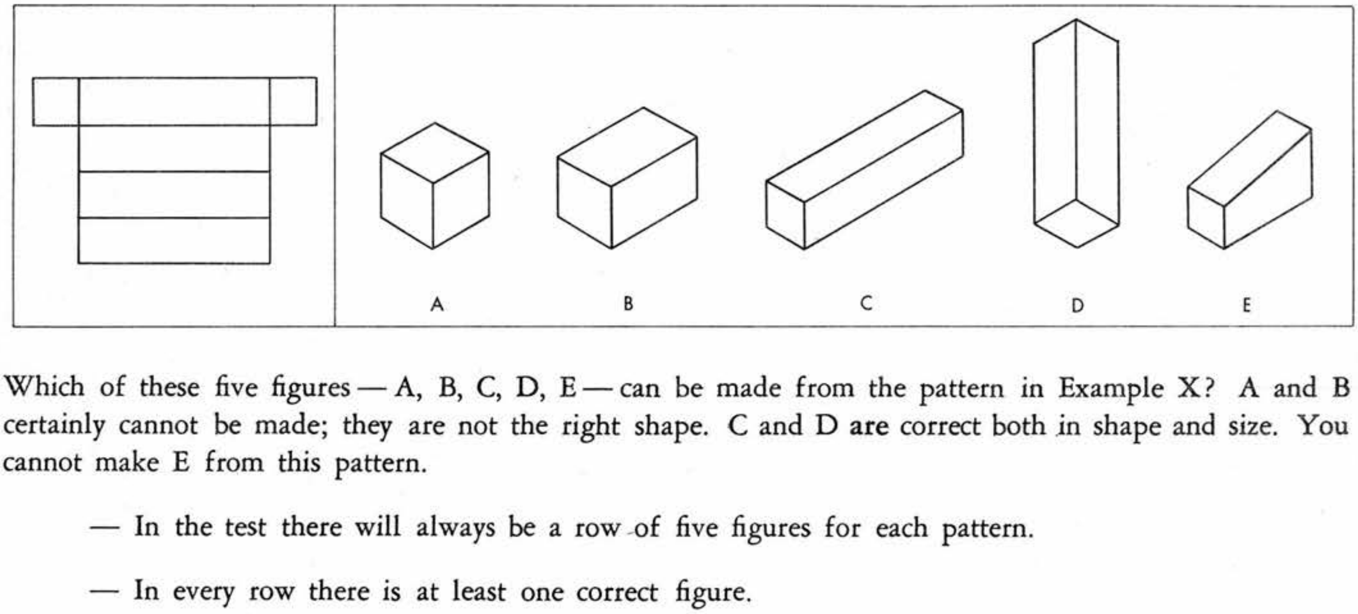
Mark your answers on the separate Answer Sheet

SPACE RELATIONS

DIRECTIONS

This test consists of forty patterns which can be folded into figures. For each pattern, five figures are shown. You are to decide which of these figures can be made from the pattern shown. The pattern always shows the outside of the figure. Here is an example:

EXAMPLE X



Which of these five figures — A, B, C, D, E — can be made from the pattern in Example X? A and B certainly cannot be made; they are not the right shape. C and D **are** correct both in shape and size. You cannot make E from this pattern.

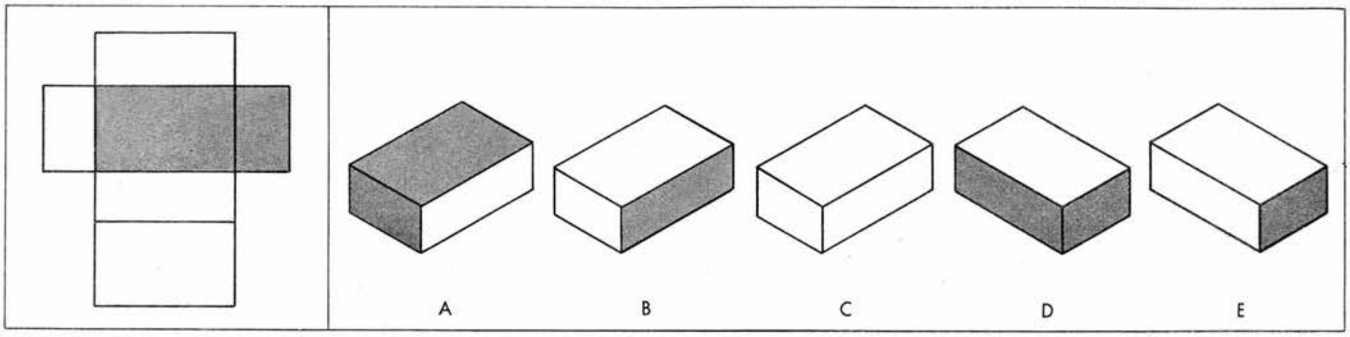
— In the test there will always be a row of five figures for each pattern.

— In every row there is at least one correct figure.

— Usually **more** than one is correct. In fact, in some cases, all five may be correct.

Now look at the pattern for Example Y and the five choices for it. Note that when the pattern is folded, the figure must have two **gray** surfaces. One of these is a large surface which could be **either** the top or bottom of a box. The other is a small surface which would be one end of the box.

Example Y



Notice — all the "boxes" made from this pattern are correct in **shape,** but the sides which you see are different. Some of these figures can be made from this pattern while others cannot. Let us look at them.

— Figure A is correct. If the large gray surface is shown as the top, then the end surface of gray can be shown facing towards you.

— Figure B is wrong. The **long, narrow** side is not gray in the pattern.

— Figure C is correct. The two gray surfaces can both be hidden by placing the large gray surface at the bottom and the gray end to the back.

— Figure D is wrong. The gray end is all right, but there is no long gray side in the pattern.

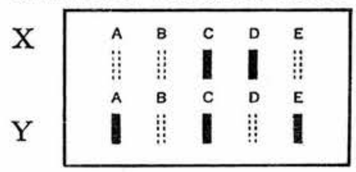
— Figure E is correct. One can show the box so that the large gray surface is at the bottom (as it was in C), but with the gray end showing at the front.

So, you see, there are three figures (A, C and E) which can be made from the pattern in Example Y, and two figures (B and D) which cannot be made from this pattern.

Remember that the surface you see in the pattern must always be the OUTSIDE surface of the completed figure.

Now let's see how we mark our answers on the separate Answer Sheet. A sample is shown here.

Sample of Answer Sheet



For Example X we found that only figures C and D could be made, so the spaces under C and D opposite X have been blackened. For Example Y, A is a correct figure, C is correct, and E is correct, so opposite Y we have blackened in the spaces under A, C and E.

In taking the test:

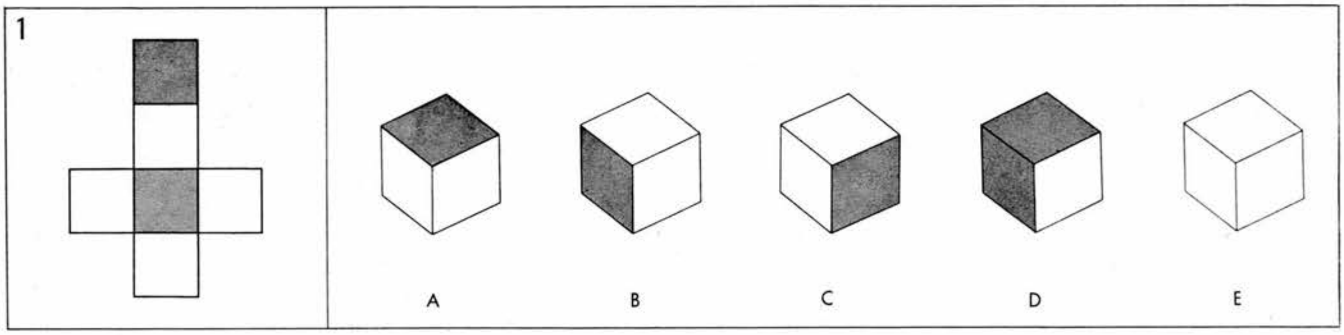
— Study each pattern.

— Decide which of the figures can be made from the pattern.

— Show your choices on the Answer Sheet by blackening in the little space under the letter which is the same as that of the figure you have chosen in the booklet.

— If you decide a certain figure cannot be made from the Pattern, make no mark on the Answer Sheet.

Do Not Write Anything in This Booklet
Use Separate Answer Sheet
You Will Be Told When to Begin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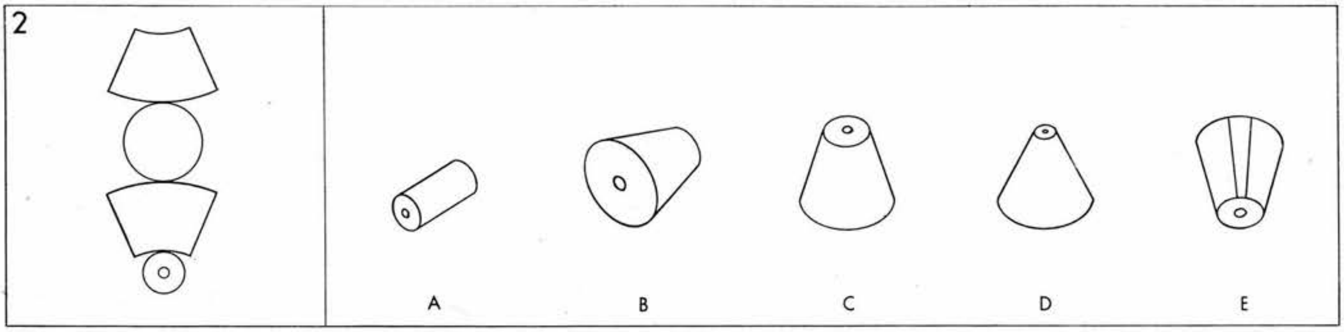
A
B
C
D
E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A
B
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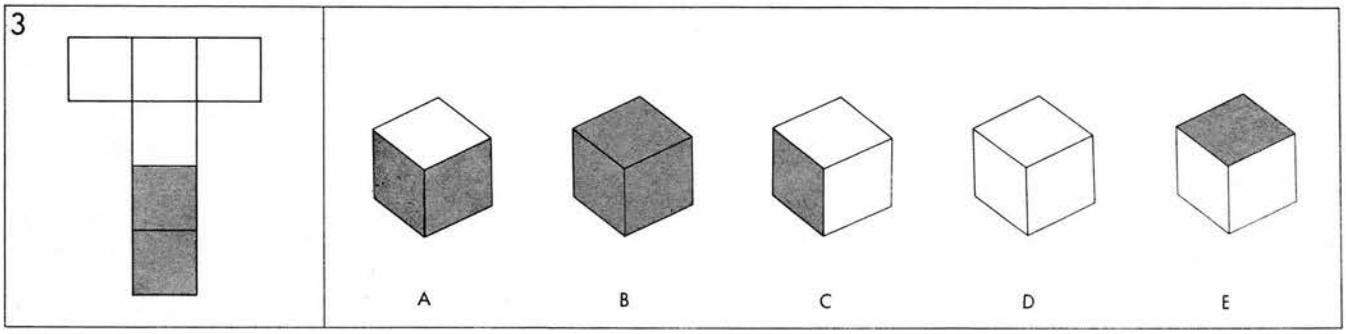
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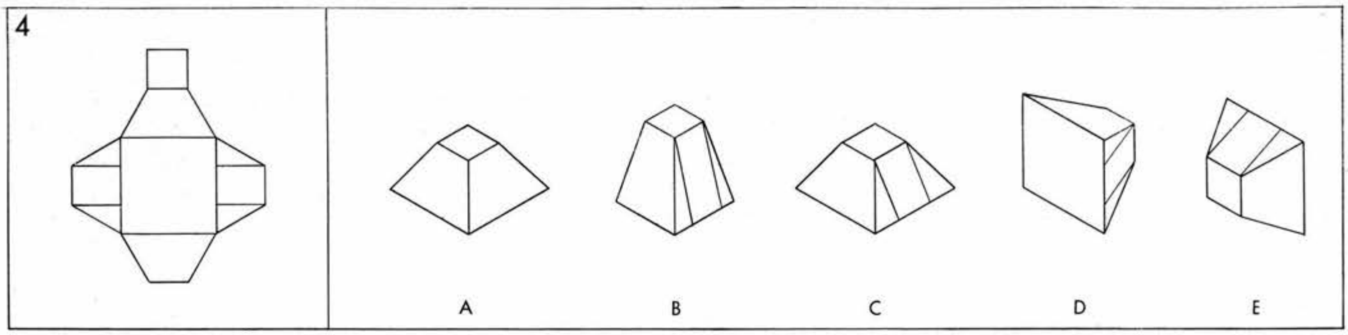
A
B
C
D
E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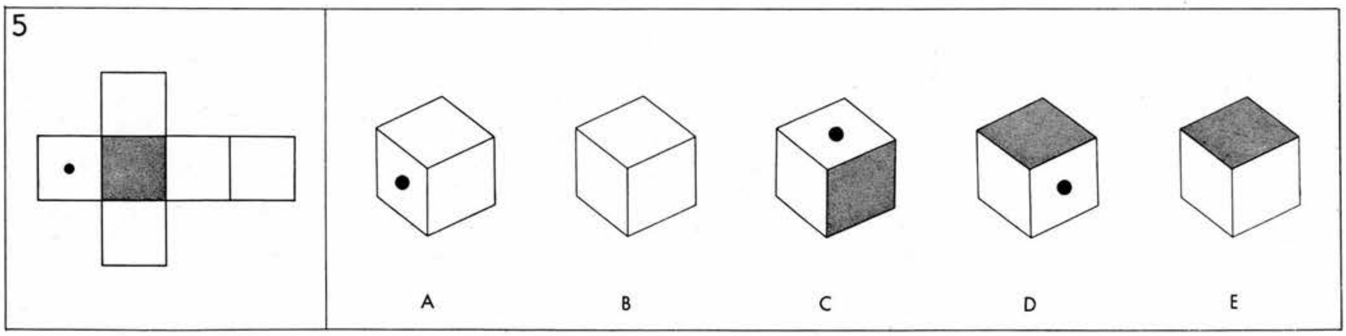
A
B
C
D
E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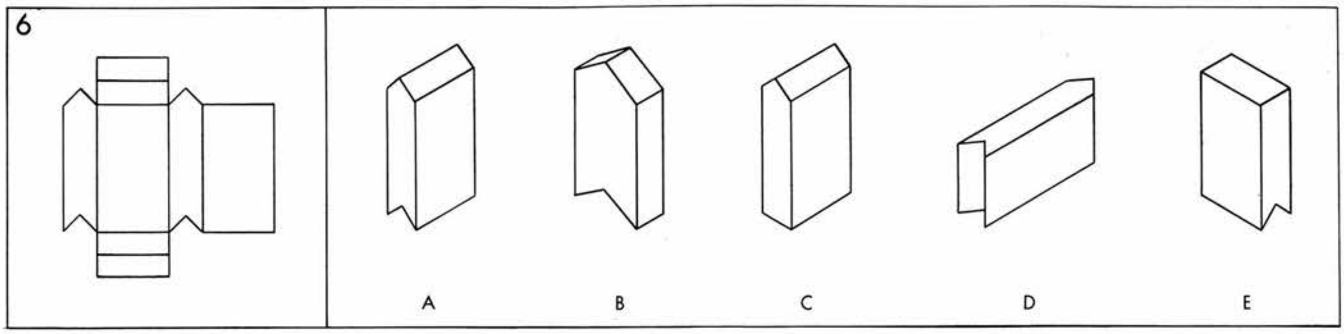
A
B
C
D
E

6



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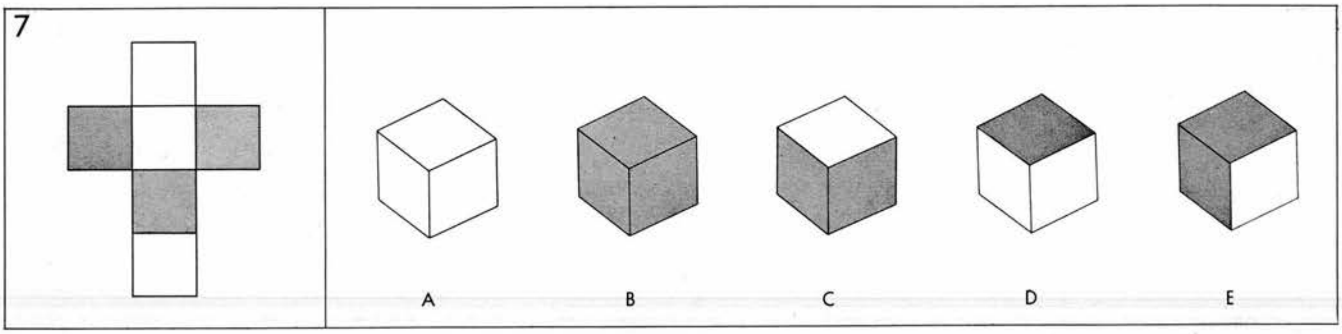

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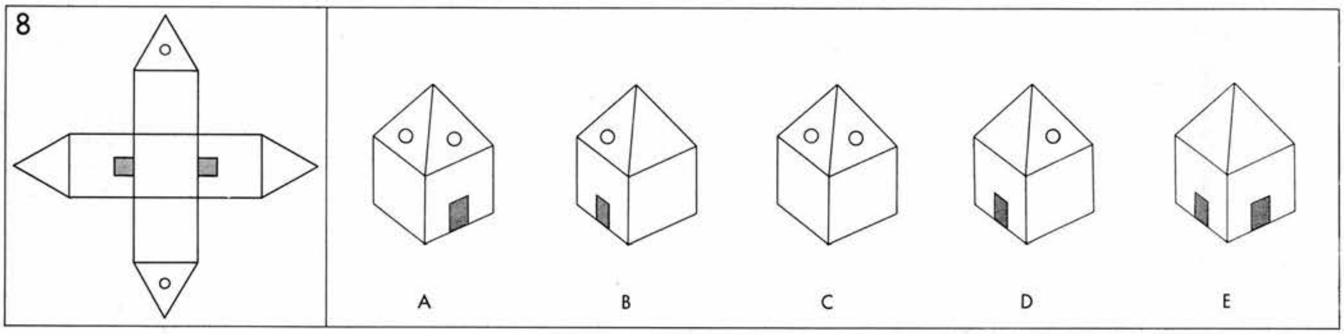

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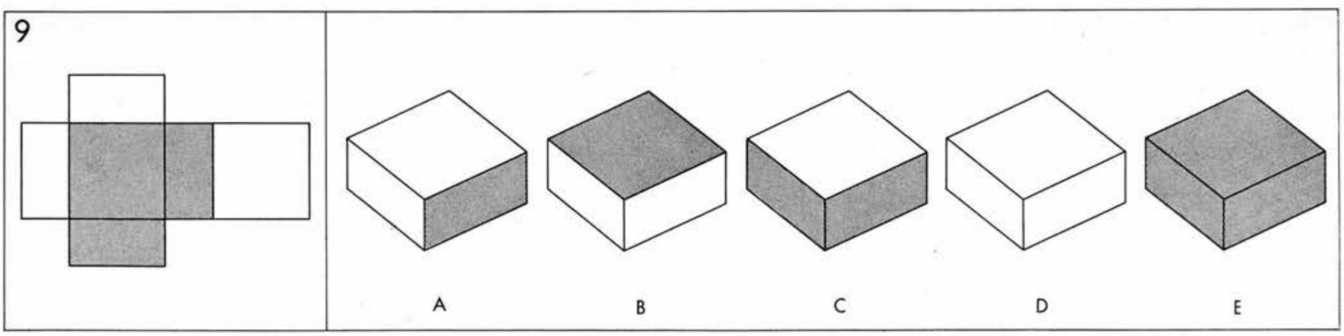

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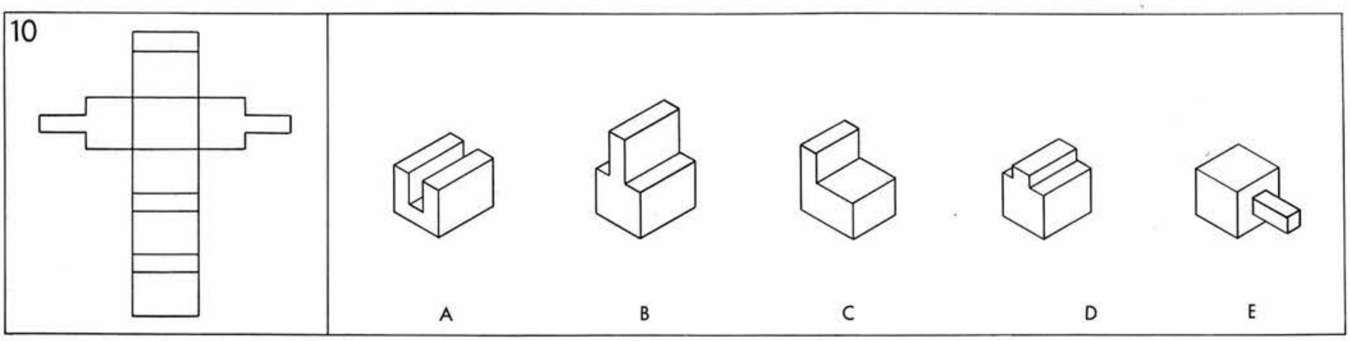

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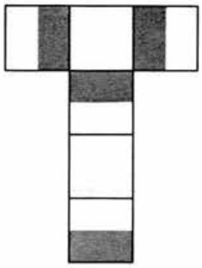

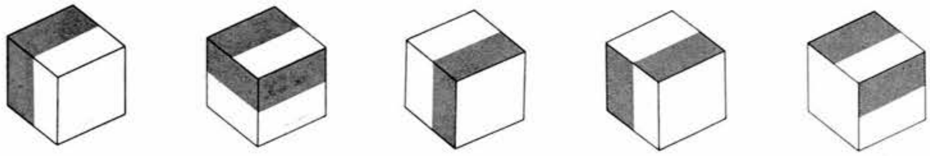

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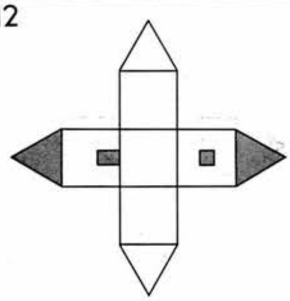

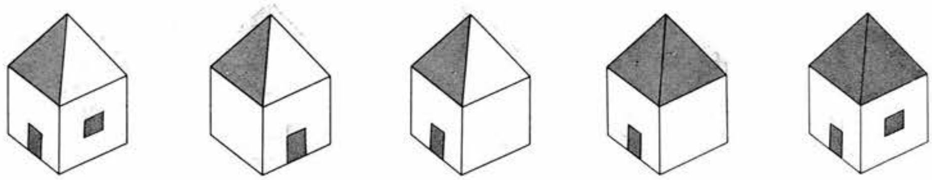

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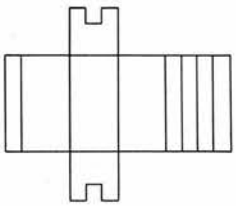

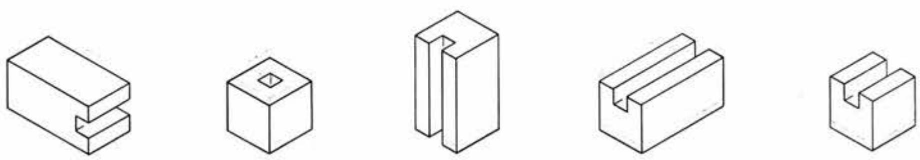

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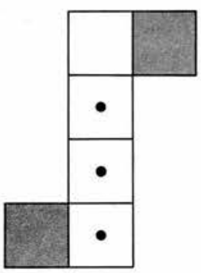

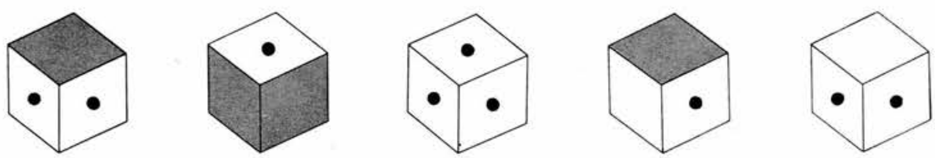

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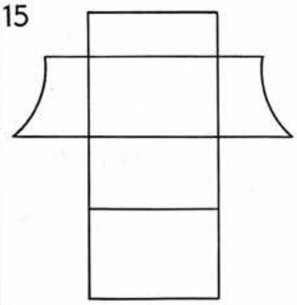

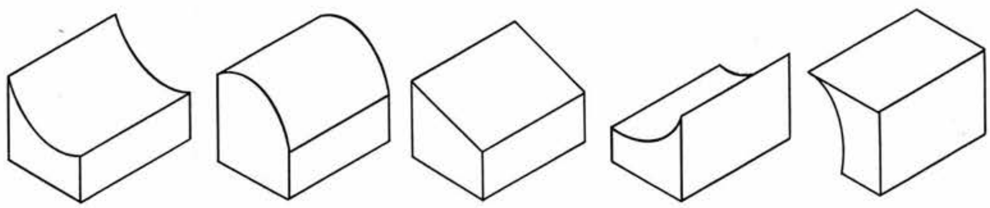

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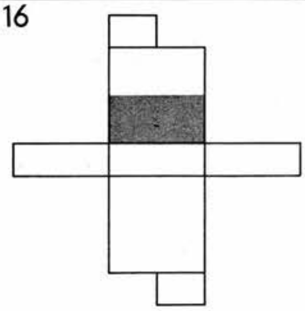

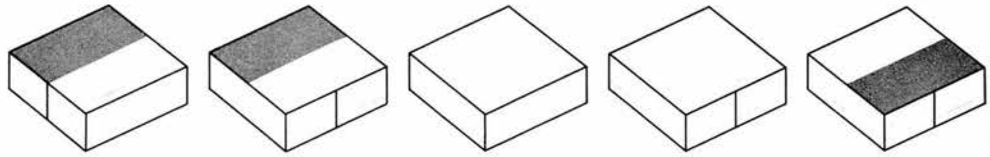

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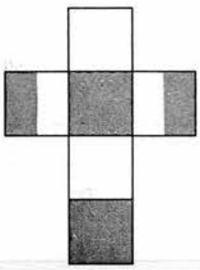

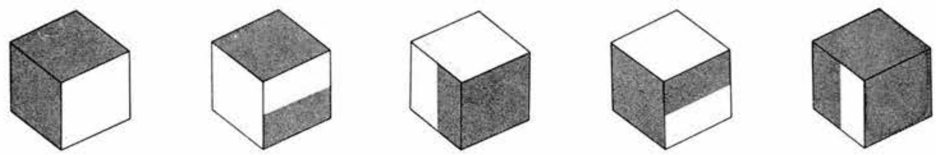

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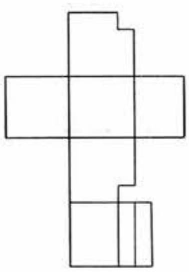

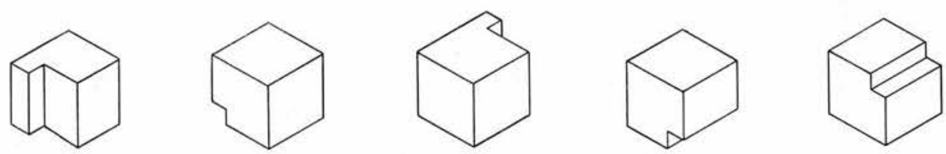

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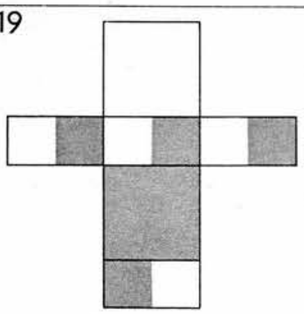

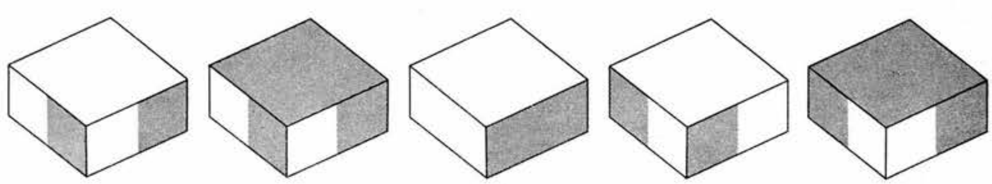

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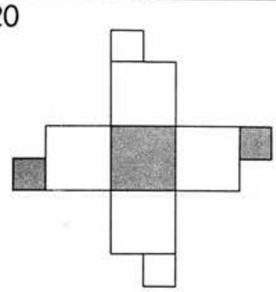

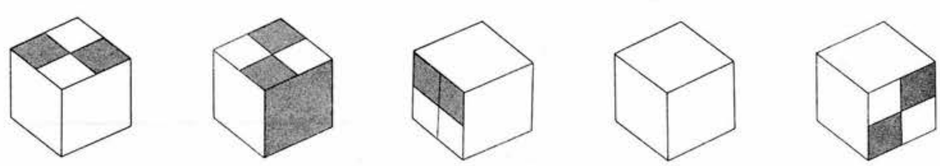

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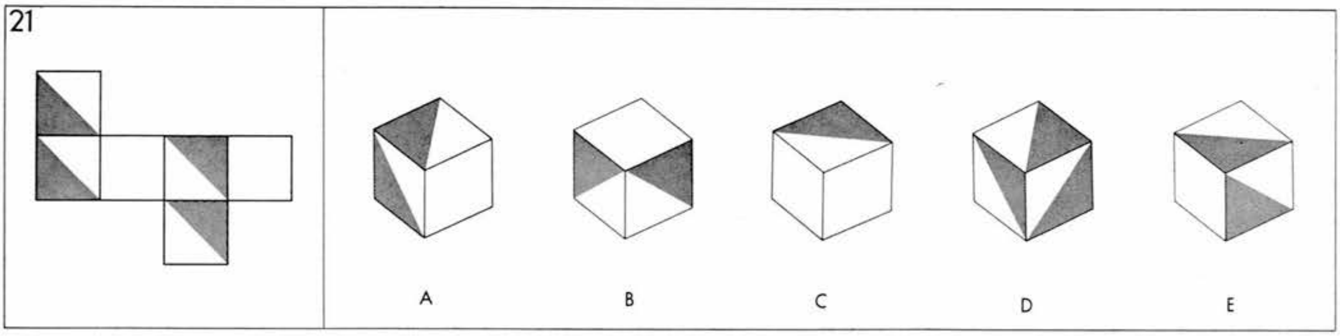

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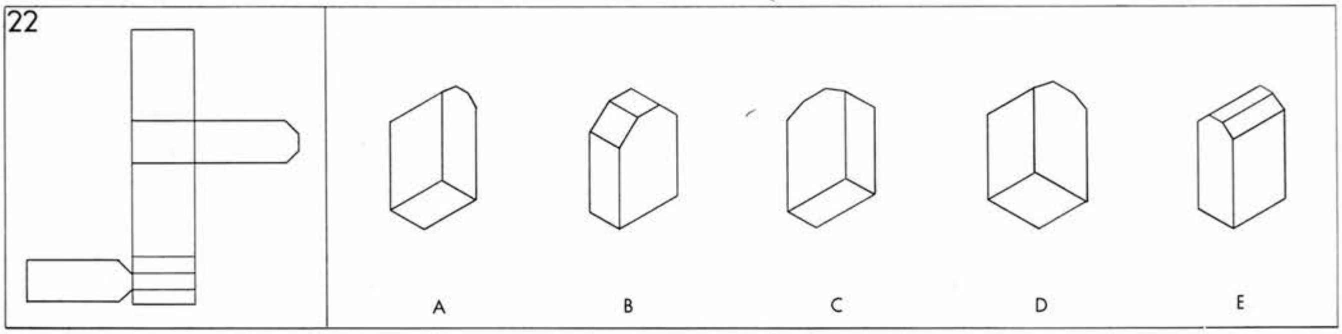

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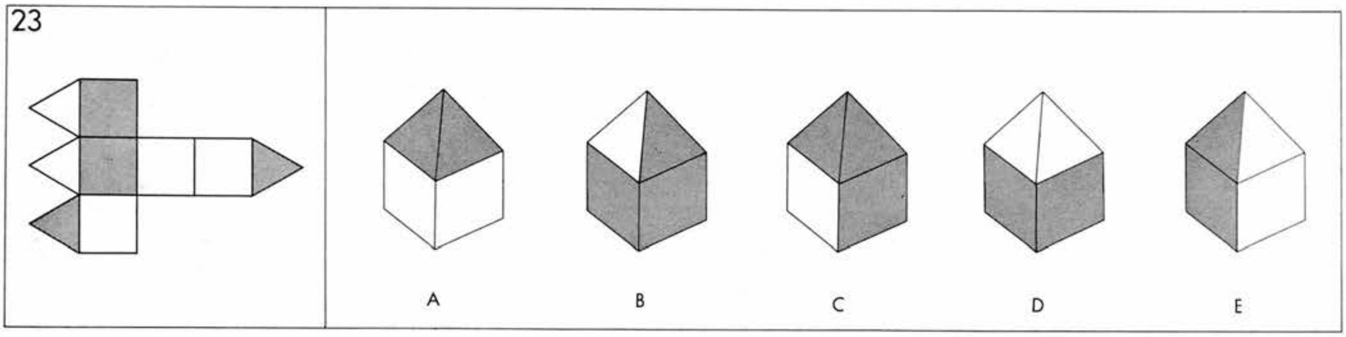

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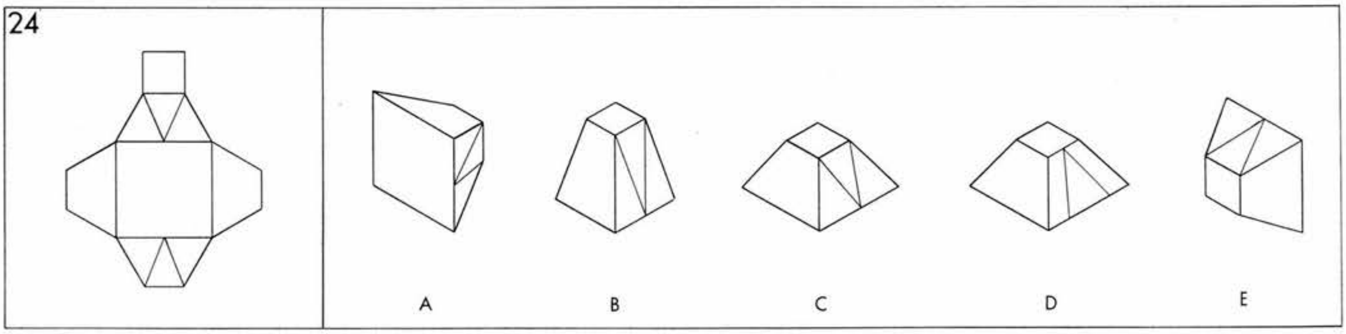

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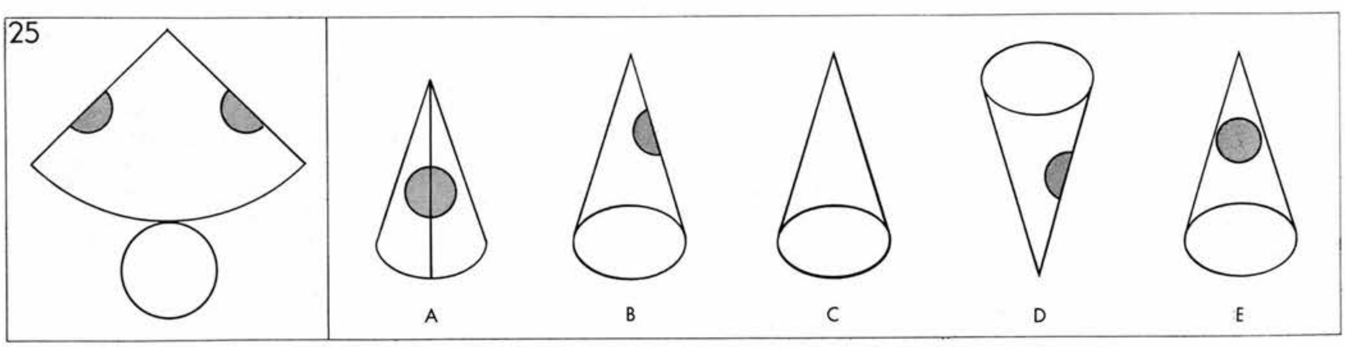

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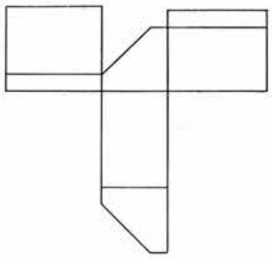

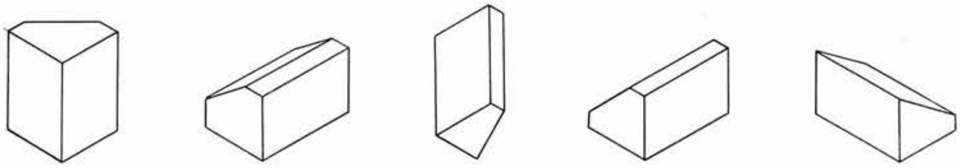

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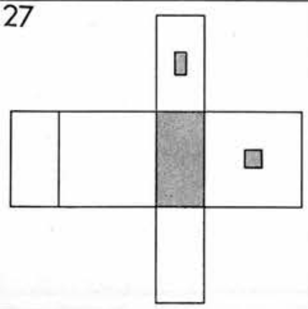

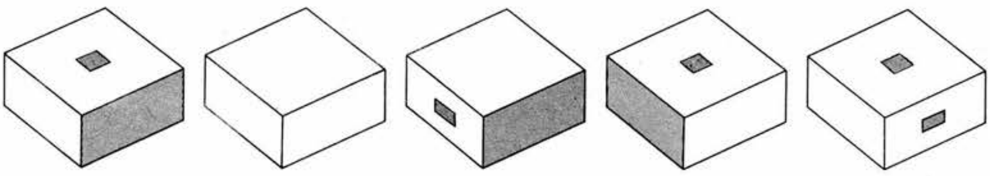

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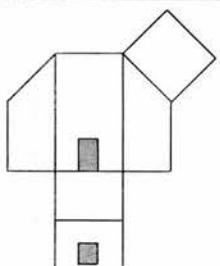

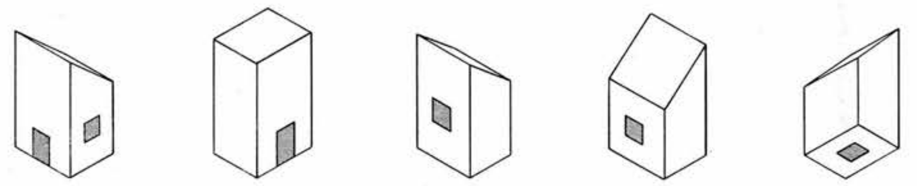

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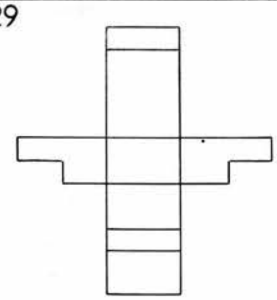

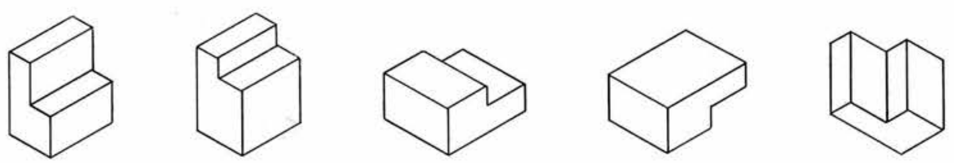

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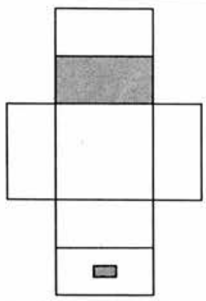

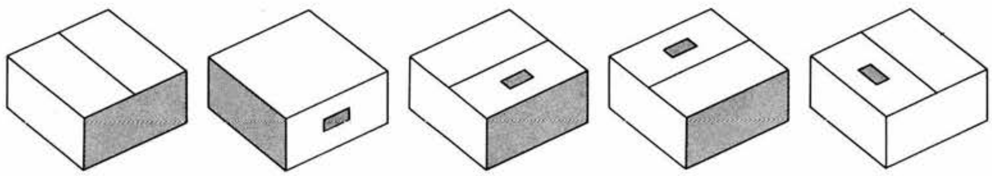

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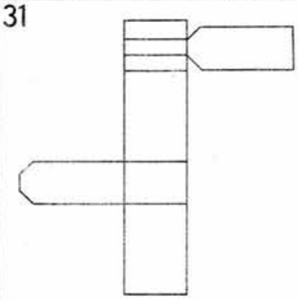

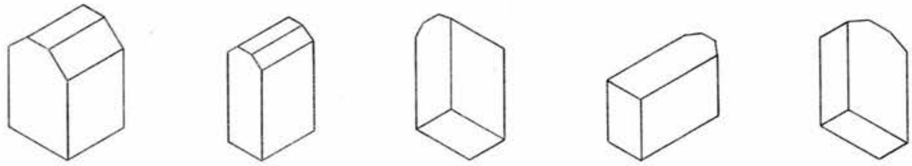

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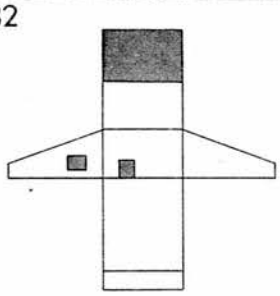

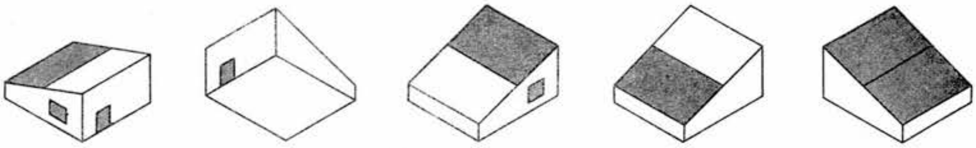

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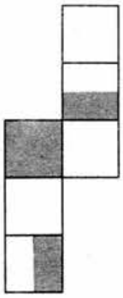

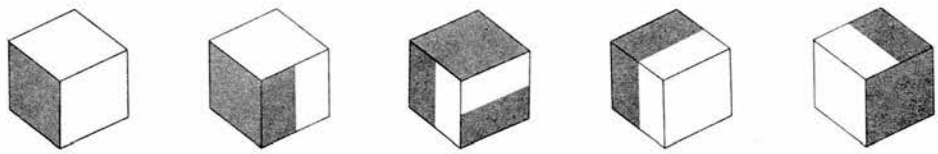

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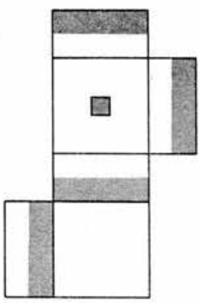

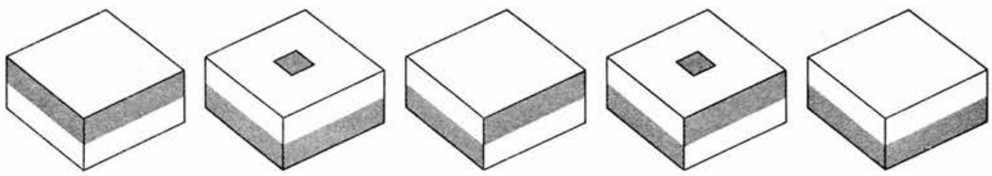

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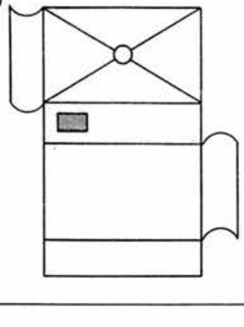

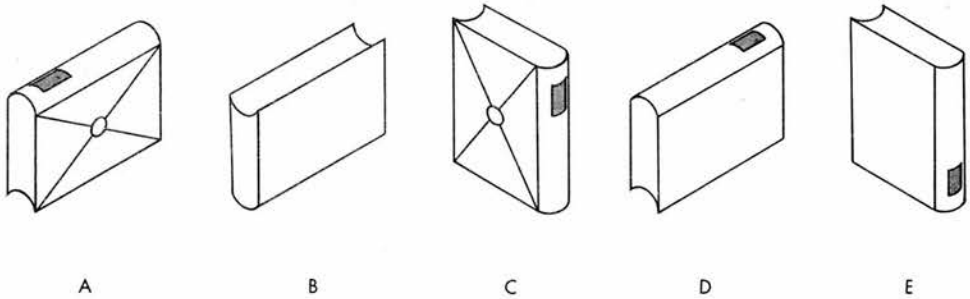

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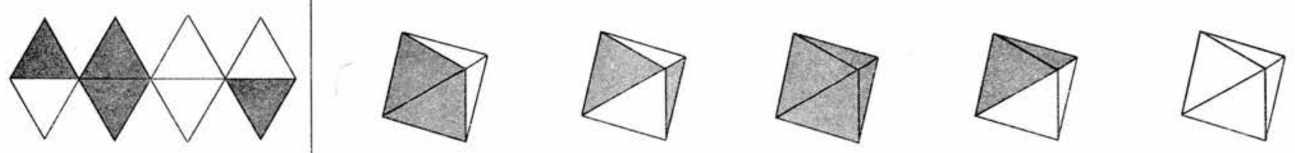

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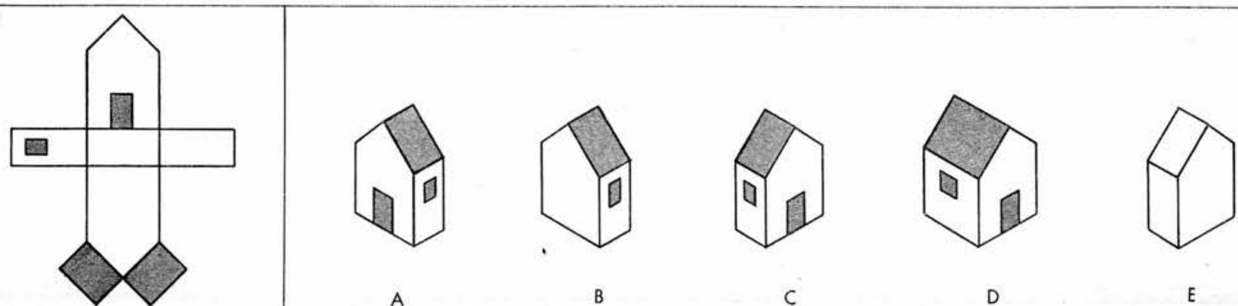

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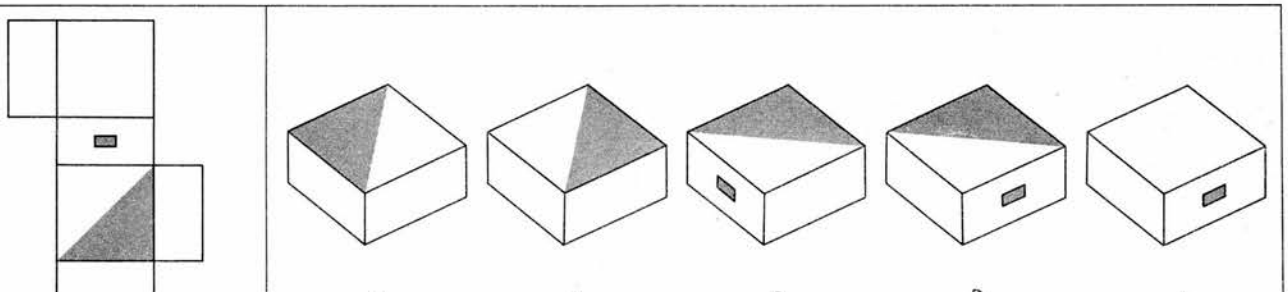

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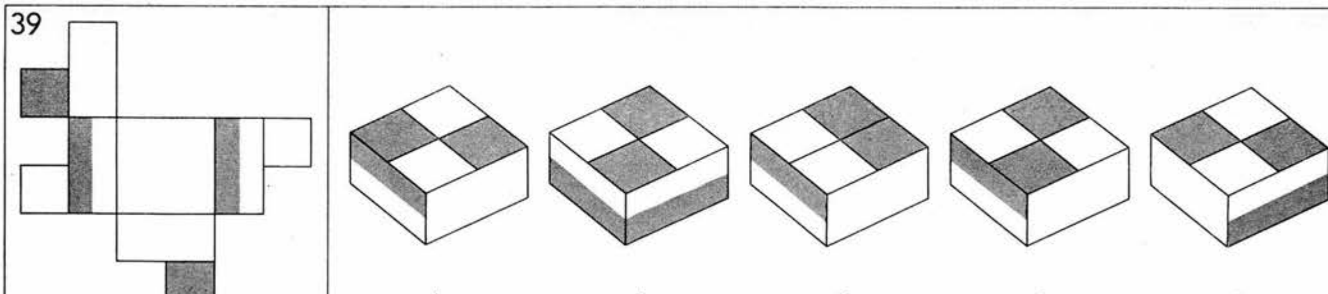

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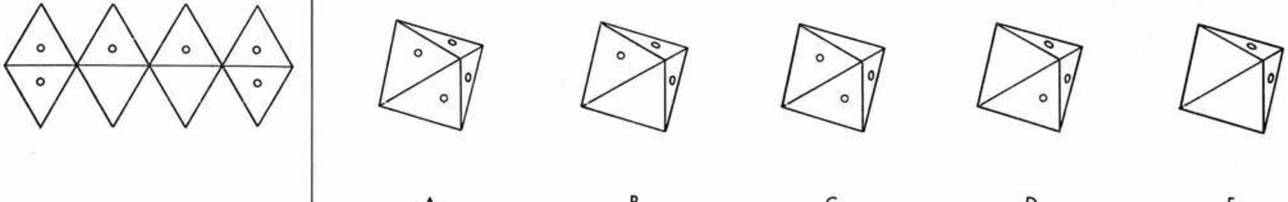


A B C D E

THE PSYCHOLOGICAL CORPORATION

INCORPORATED IN 1921 ®

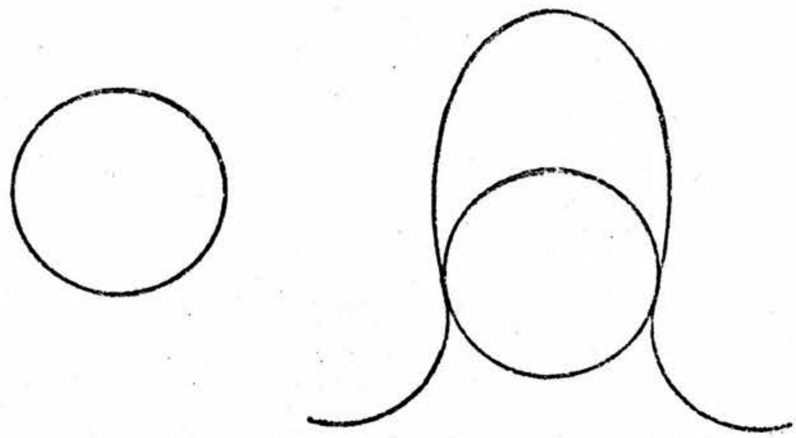
EMBEDDED FIGURE TEST

PROJECT ONE

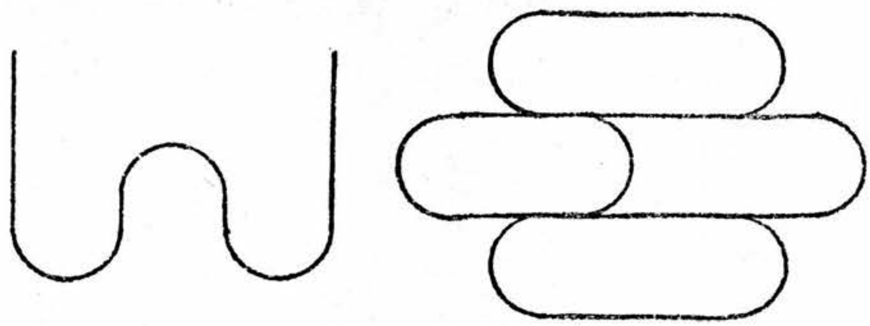
(pages 565 - 570)

EMBEDDED FIGURE TEST (EFT)

EFT DEMONSTRATION 1



EFT DEMONSTRATION 2



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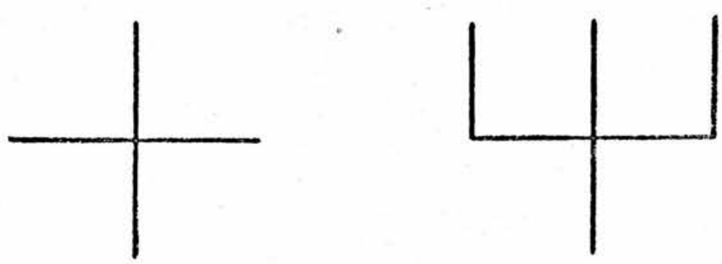

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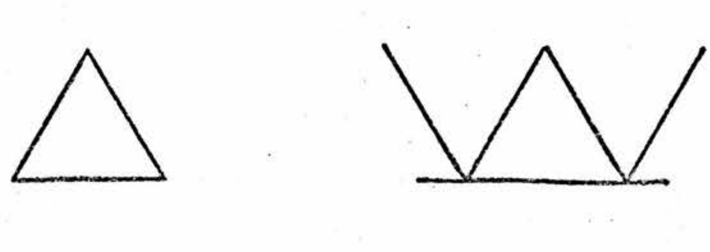

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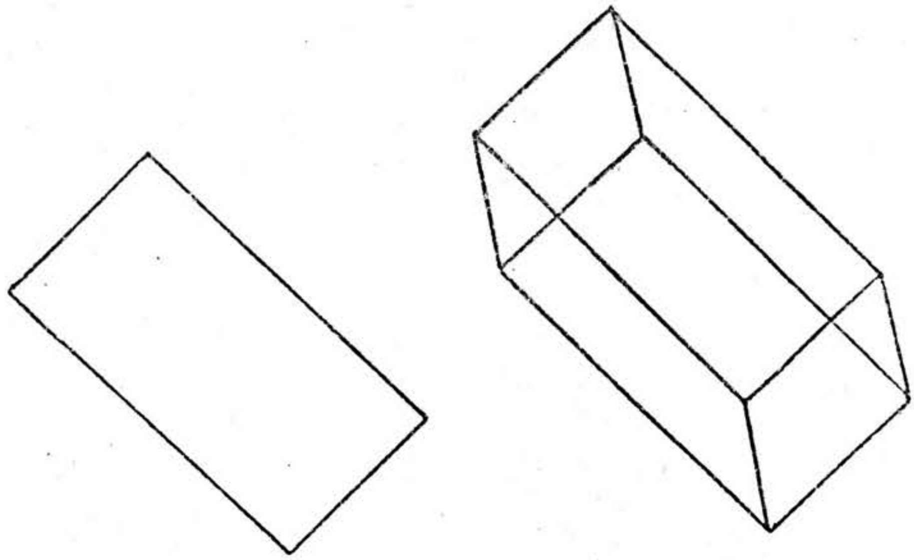

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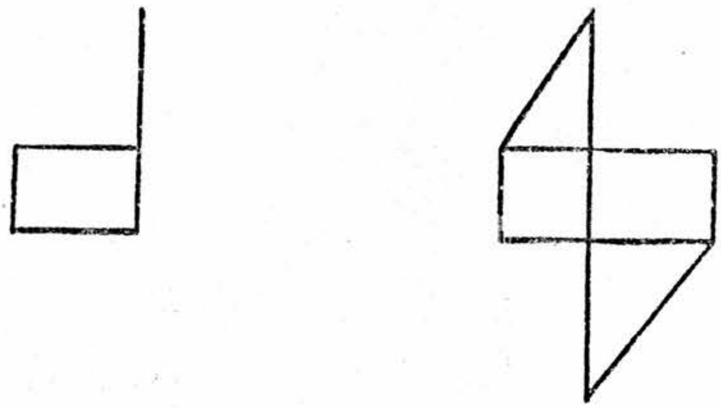

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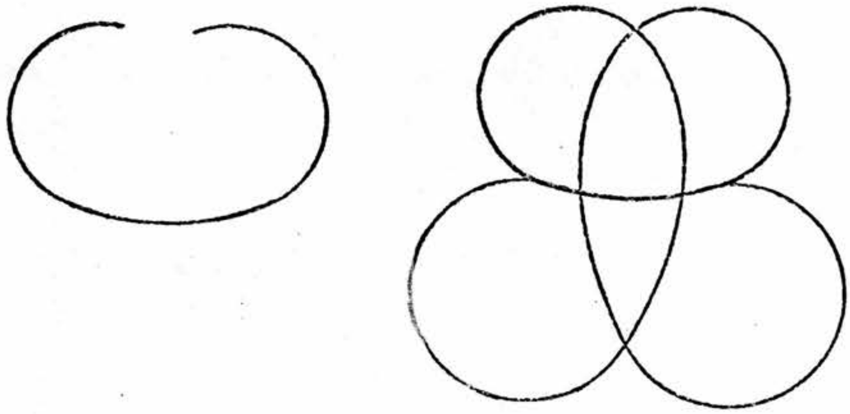

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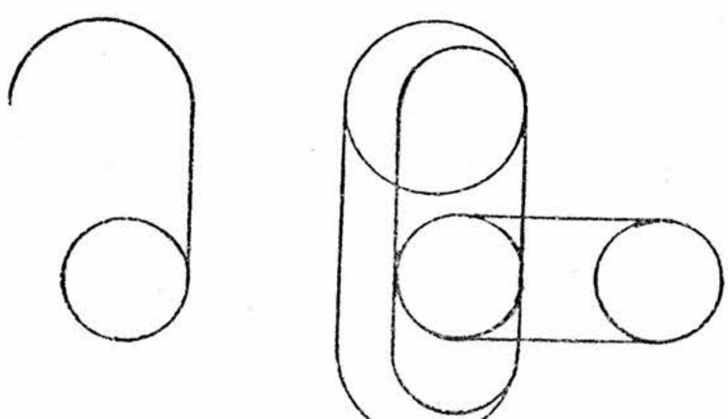

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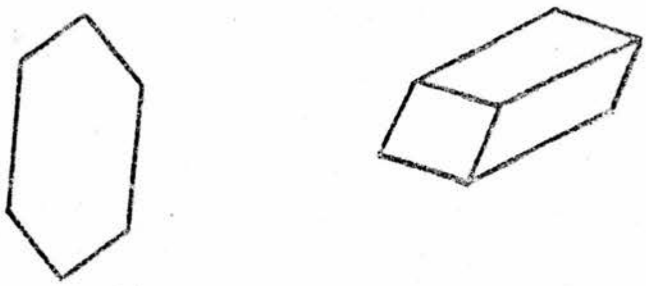

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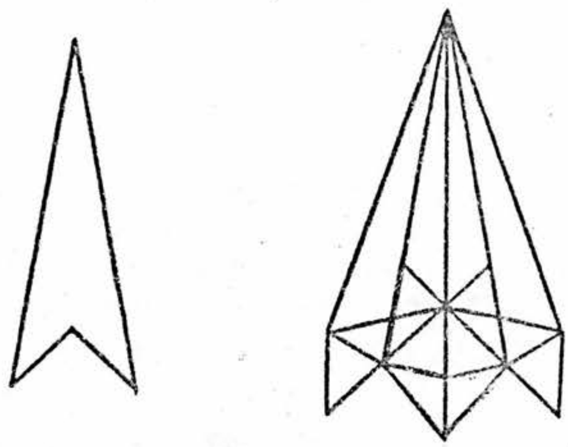

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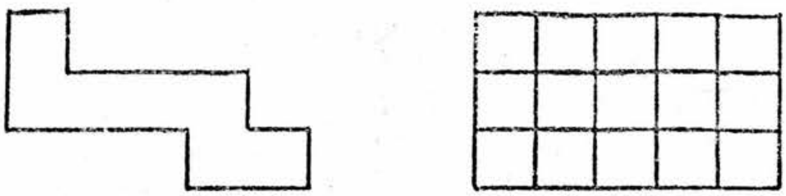

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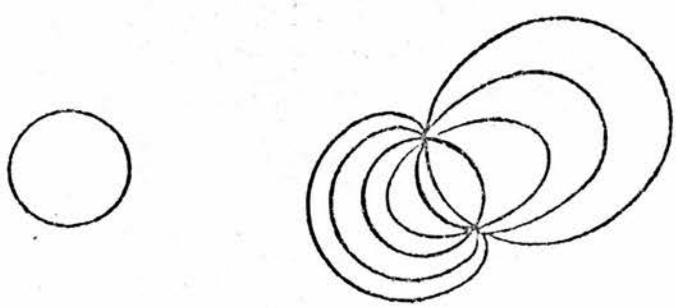

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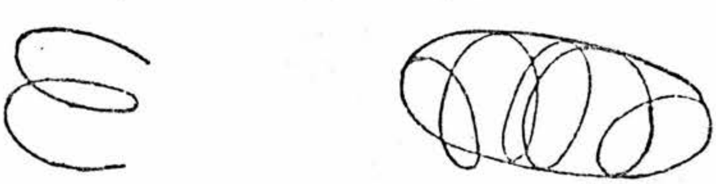

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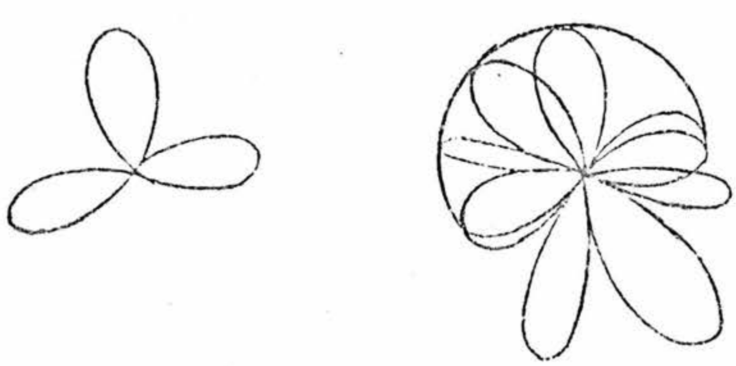

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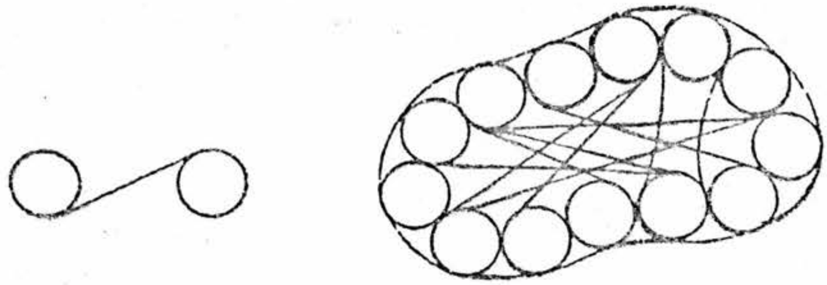

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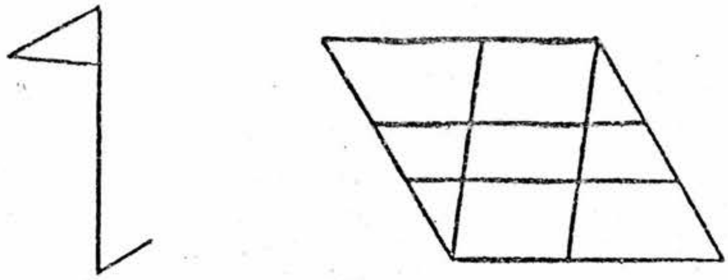

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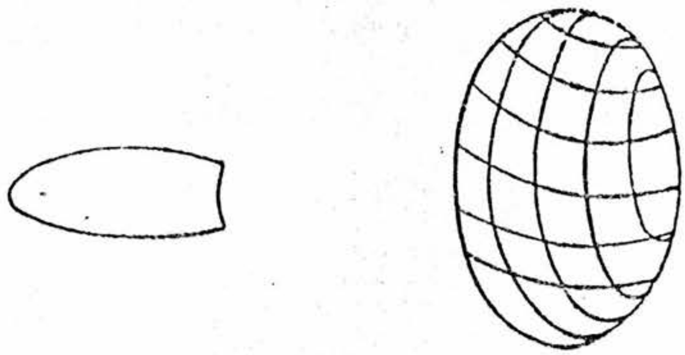

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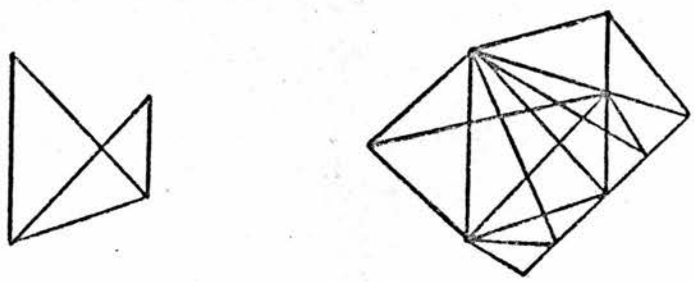

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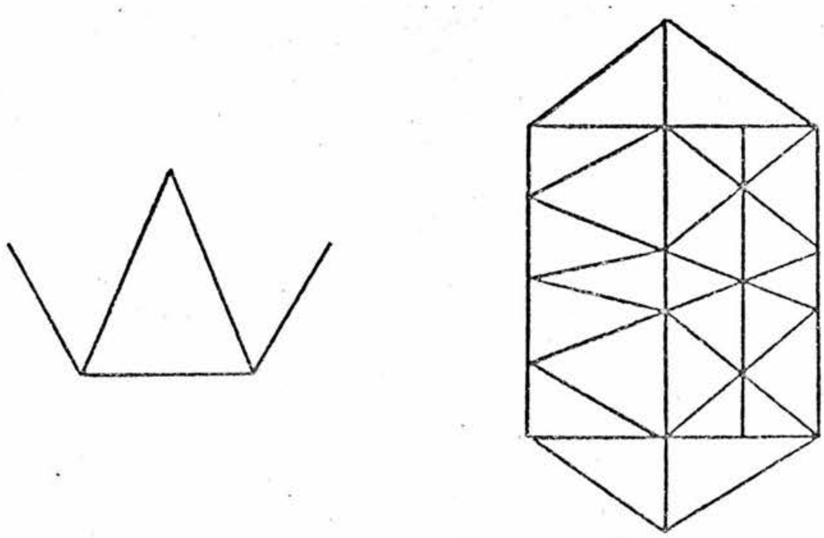

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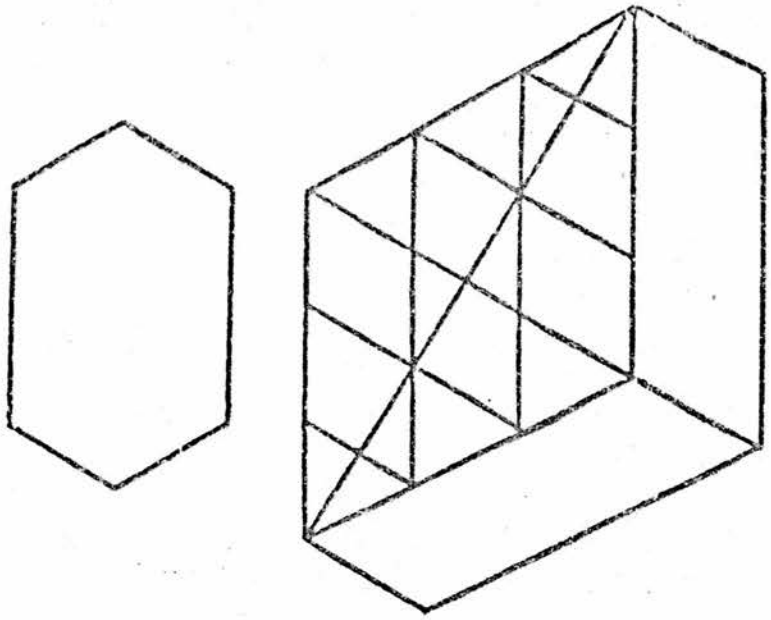
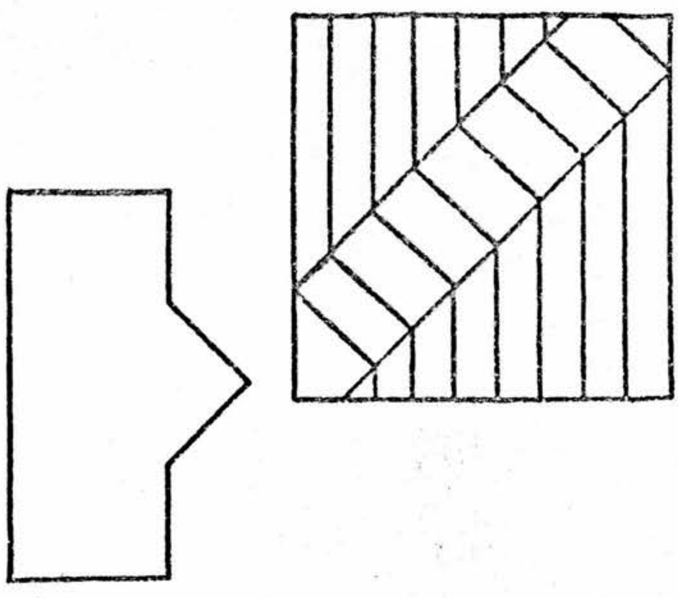


EFT 19



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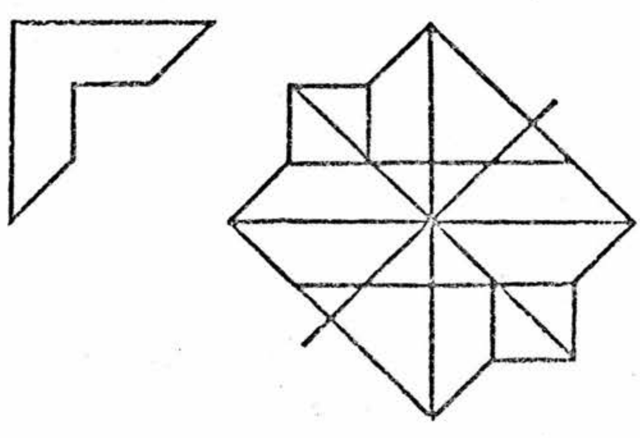

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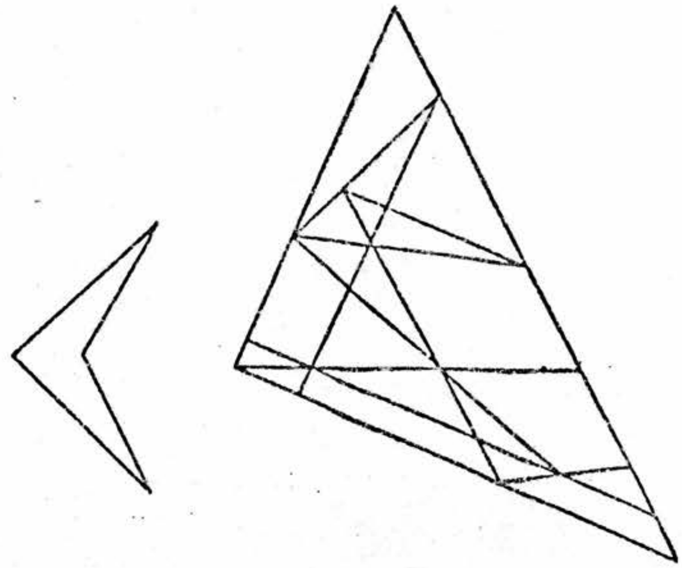
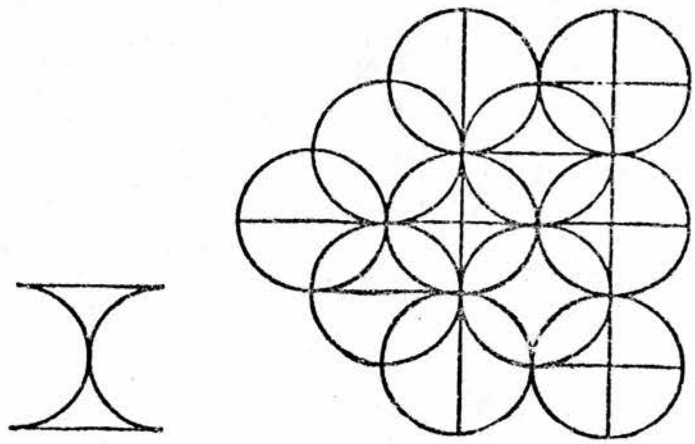
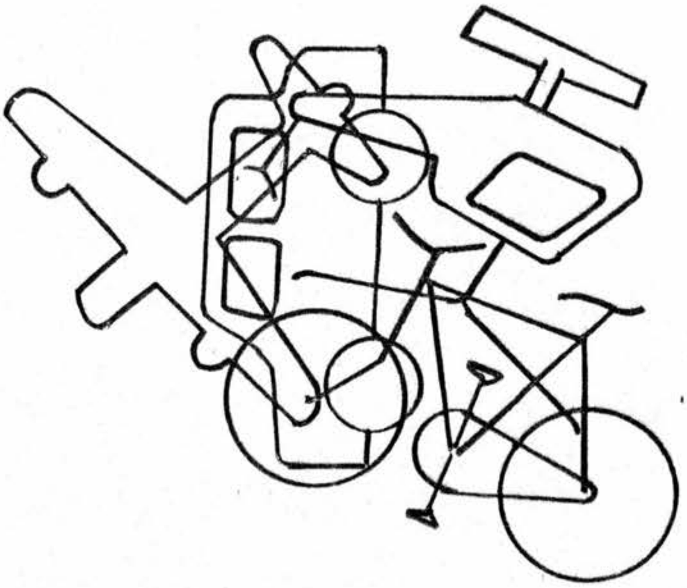
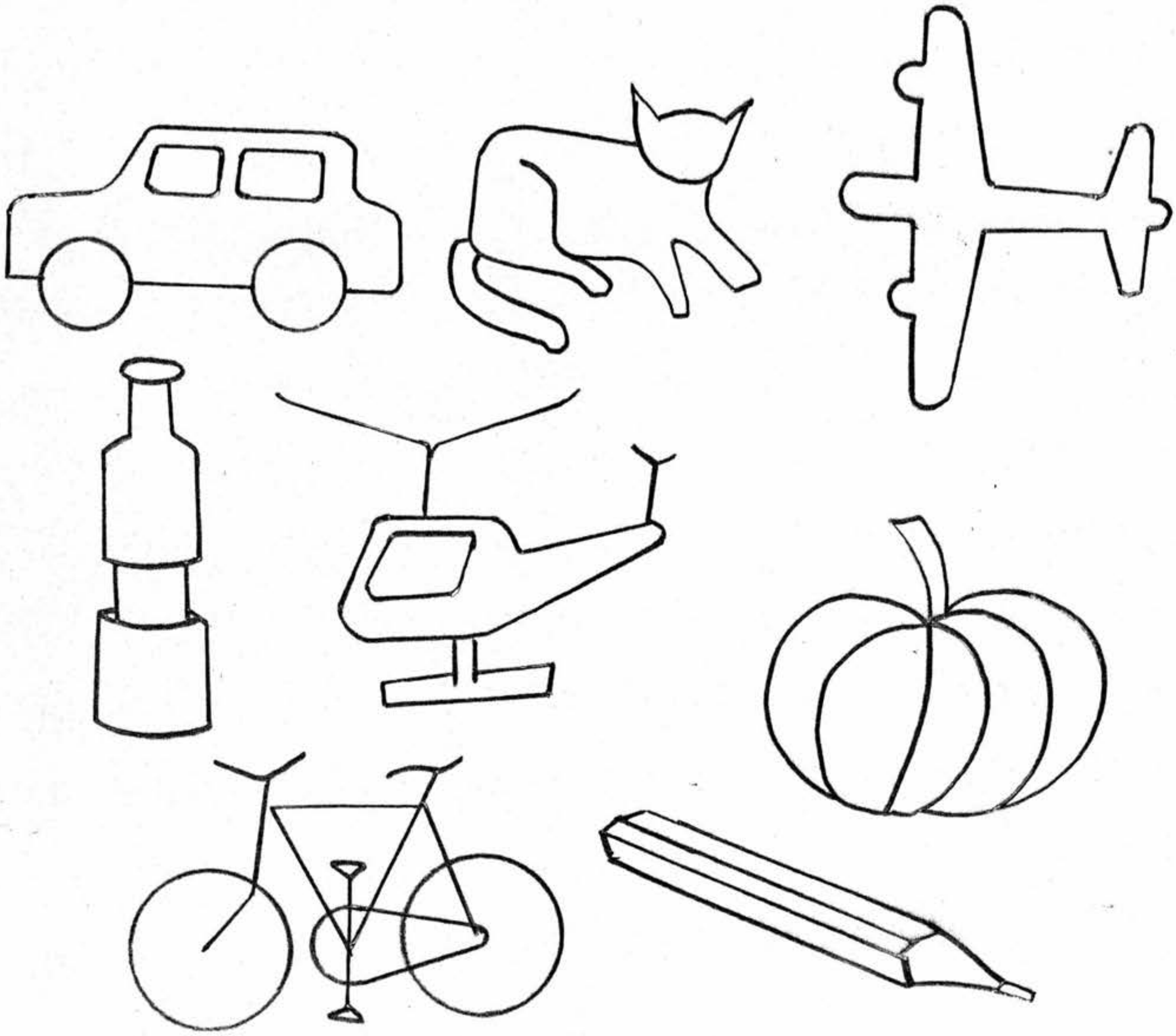


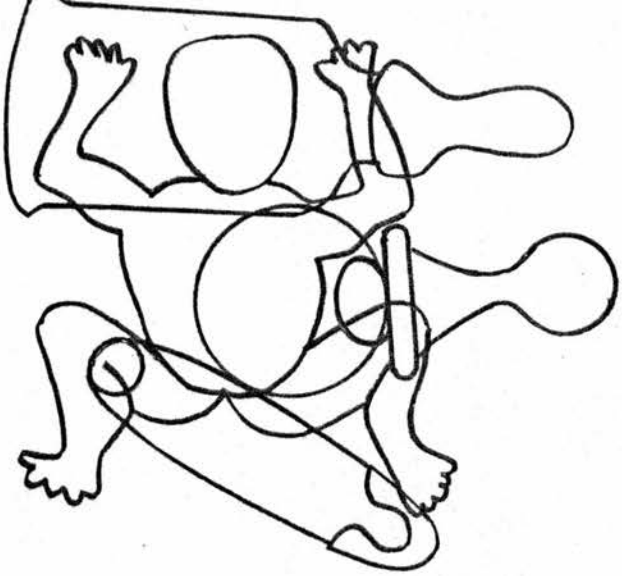
EFT 22

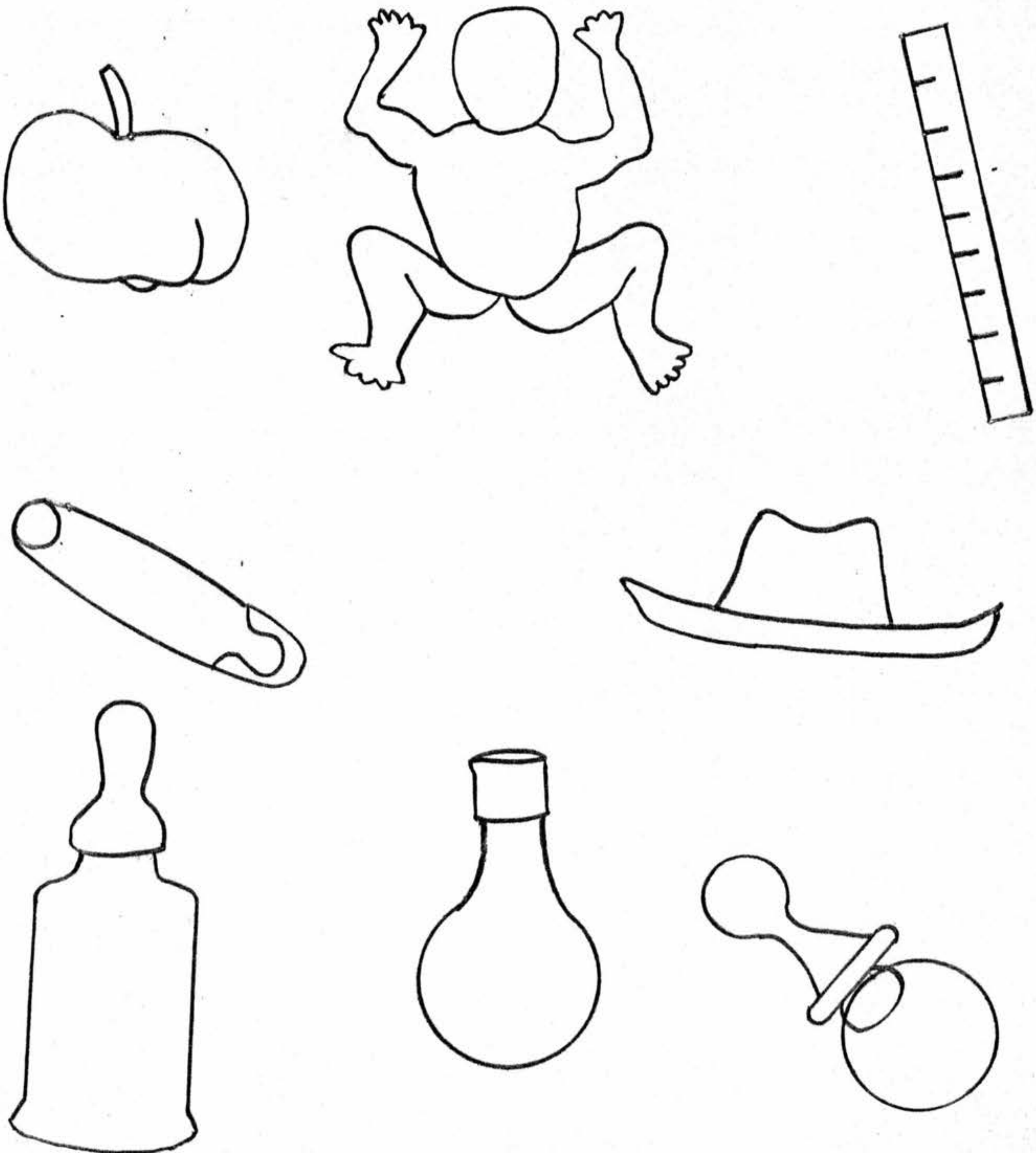


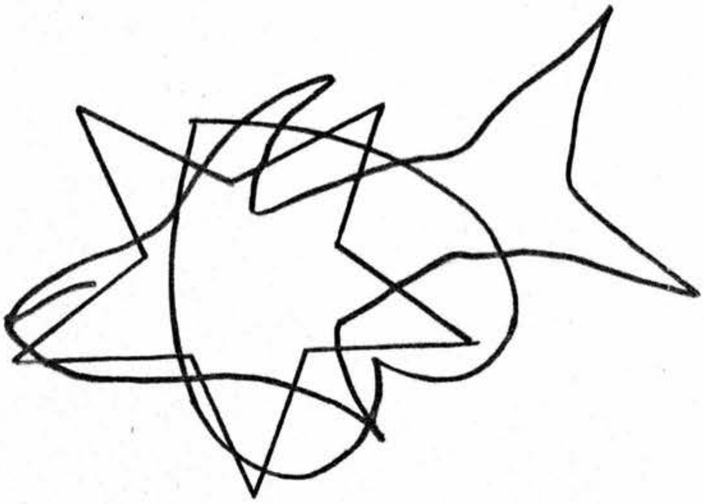
OVERLAPPING SHAPES (SIANN 1970)

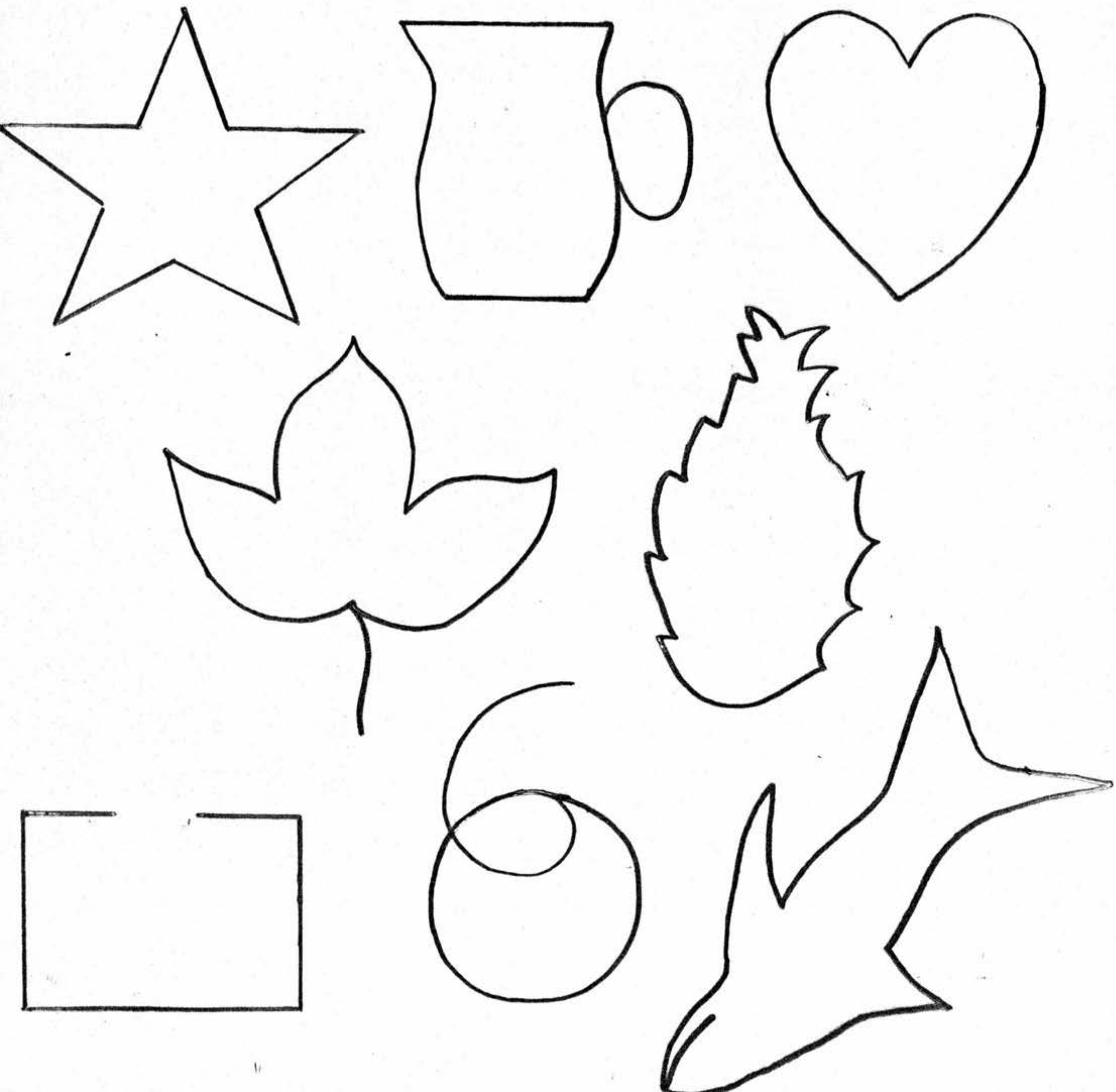








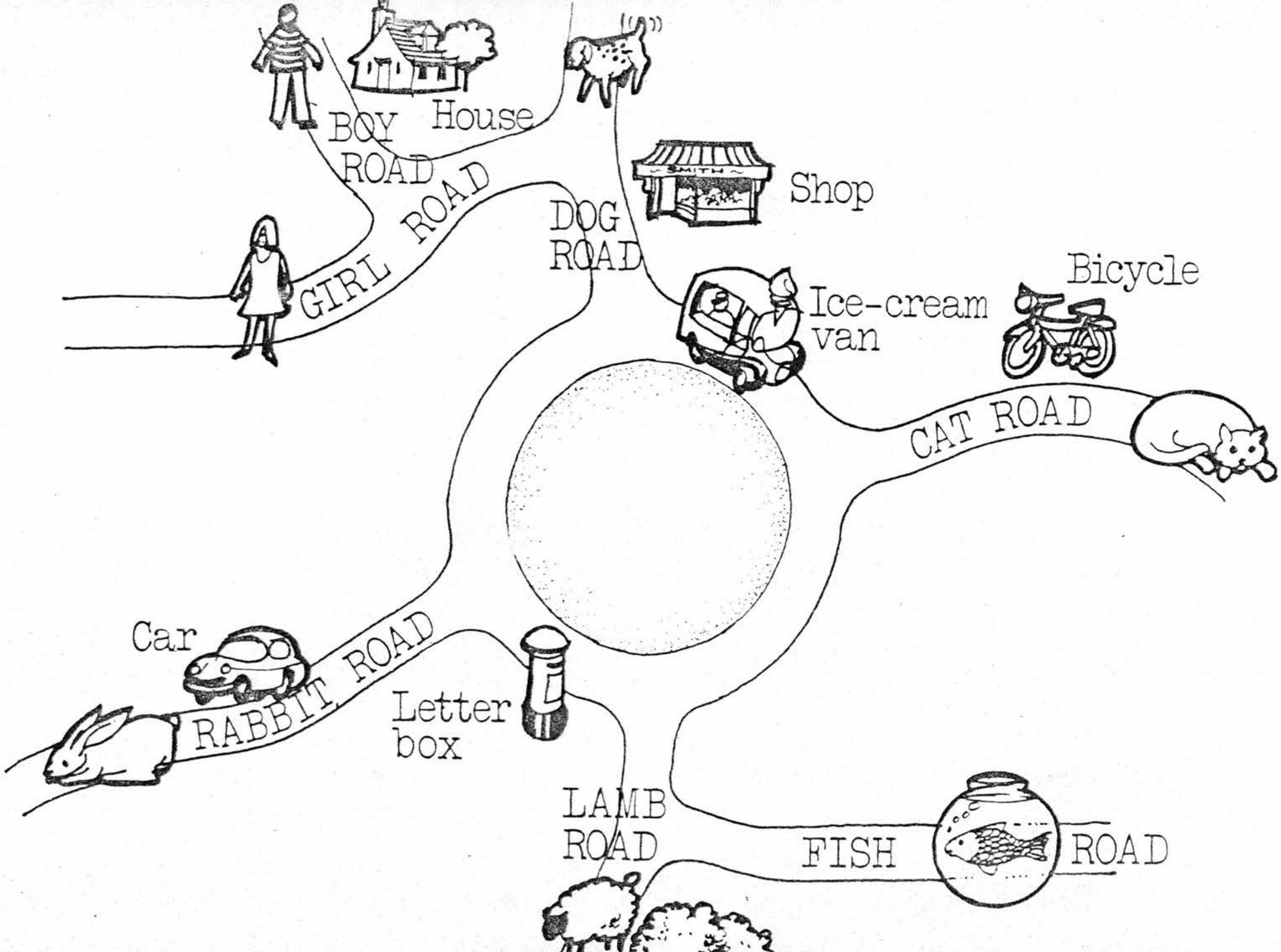




MAP 1

PROJECT ONE

(page 574)


BOY ROAD
House
GIRL ROAD
DOG ROAD
SMITH
Shop
Ice-cream van
Bicycle
CAT ROAD
Car
RABBIT ROAD
Letter box
LAMB ROAD
FISH ROAD

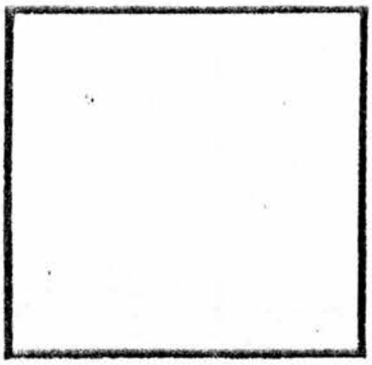
KEOGH AND MEANINGFUL KEOGH SHAPES

PROJECT ONE

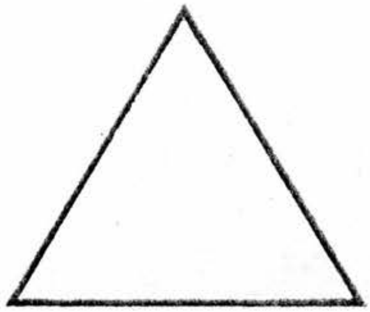
(pages 575 - 577)

KEOGH SHAPES

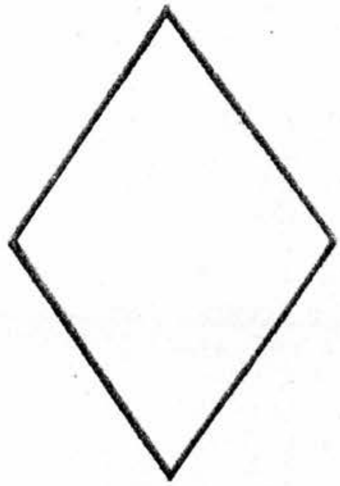
TOP SHAPES - KEOGH
LOWER SHAPES - MEANINGFUL KEOGH



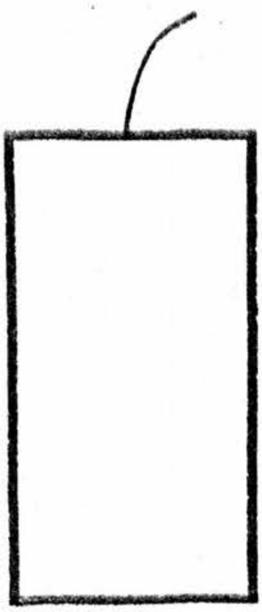
K 1



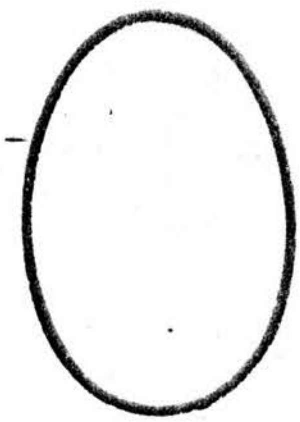
K 2



K 3



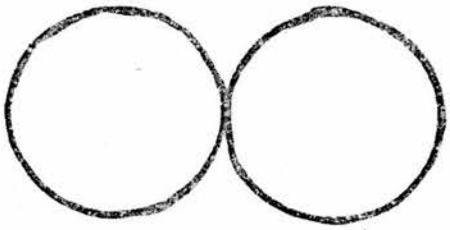
MK 1

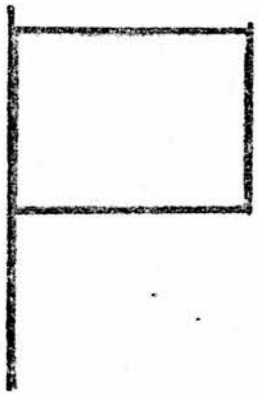


MK 2

MK 3


K 4


K 5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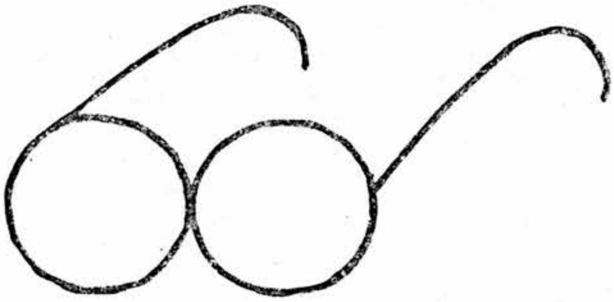
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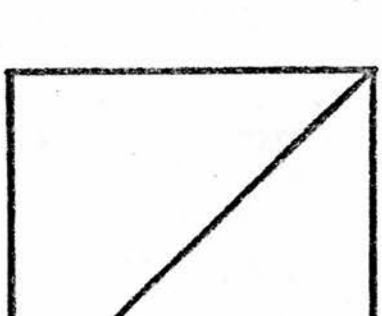
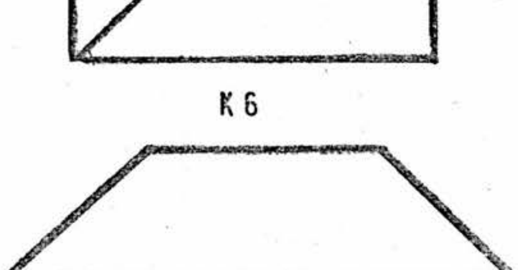

K 6


K 7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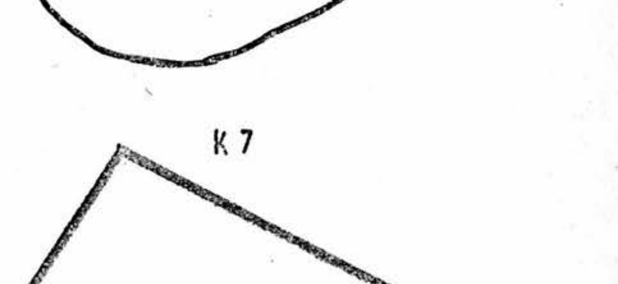
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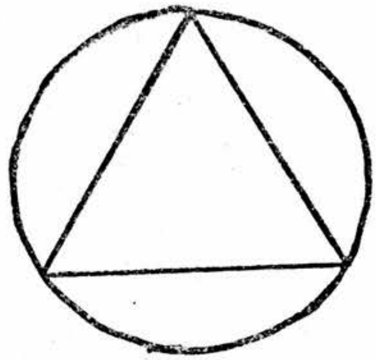


K 8

K 9

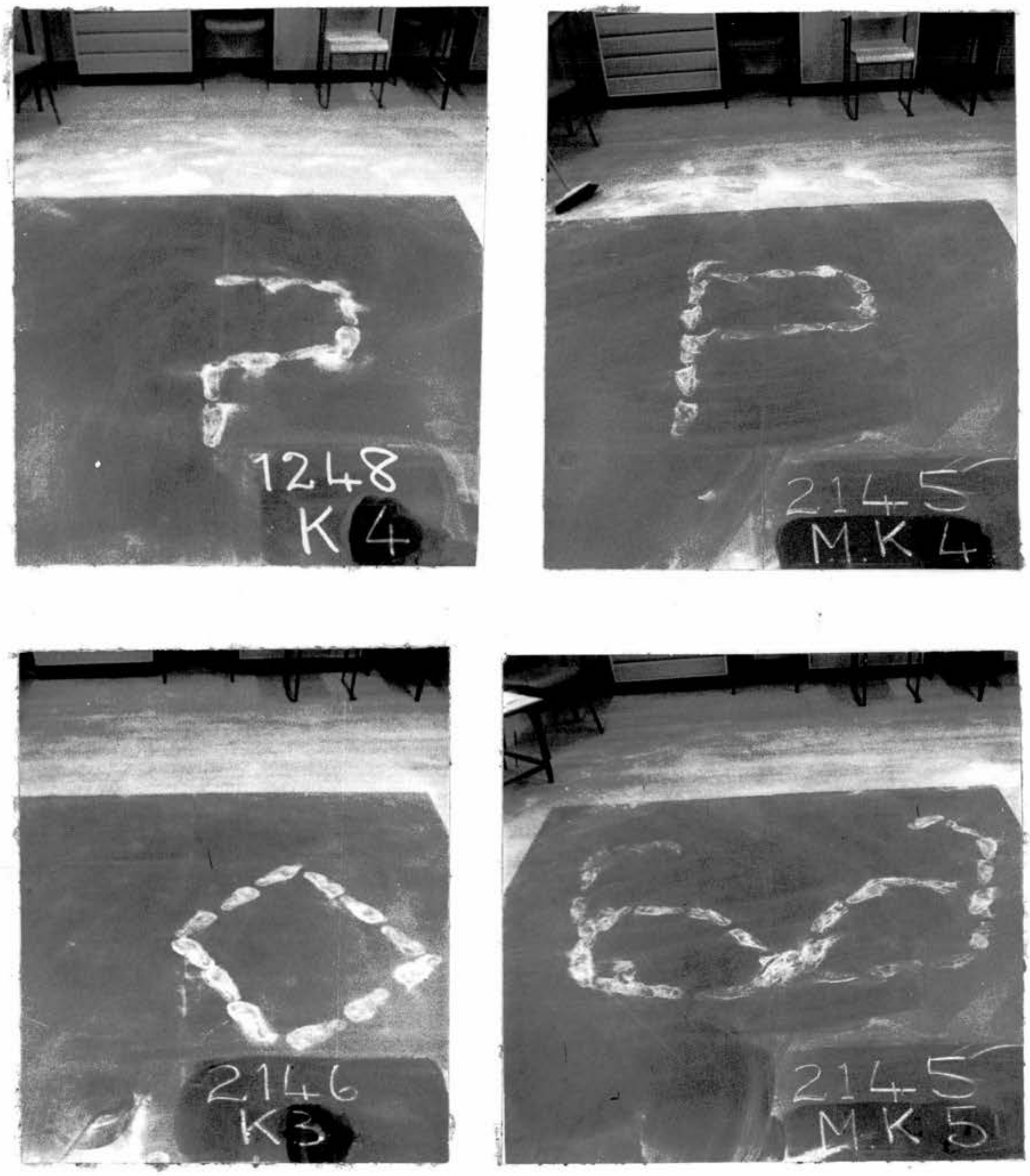
MK 8

MK 9

PHOTOGRAPHS OF KEOGH RECORDS

PROJECT ONE

(page 578)

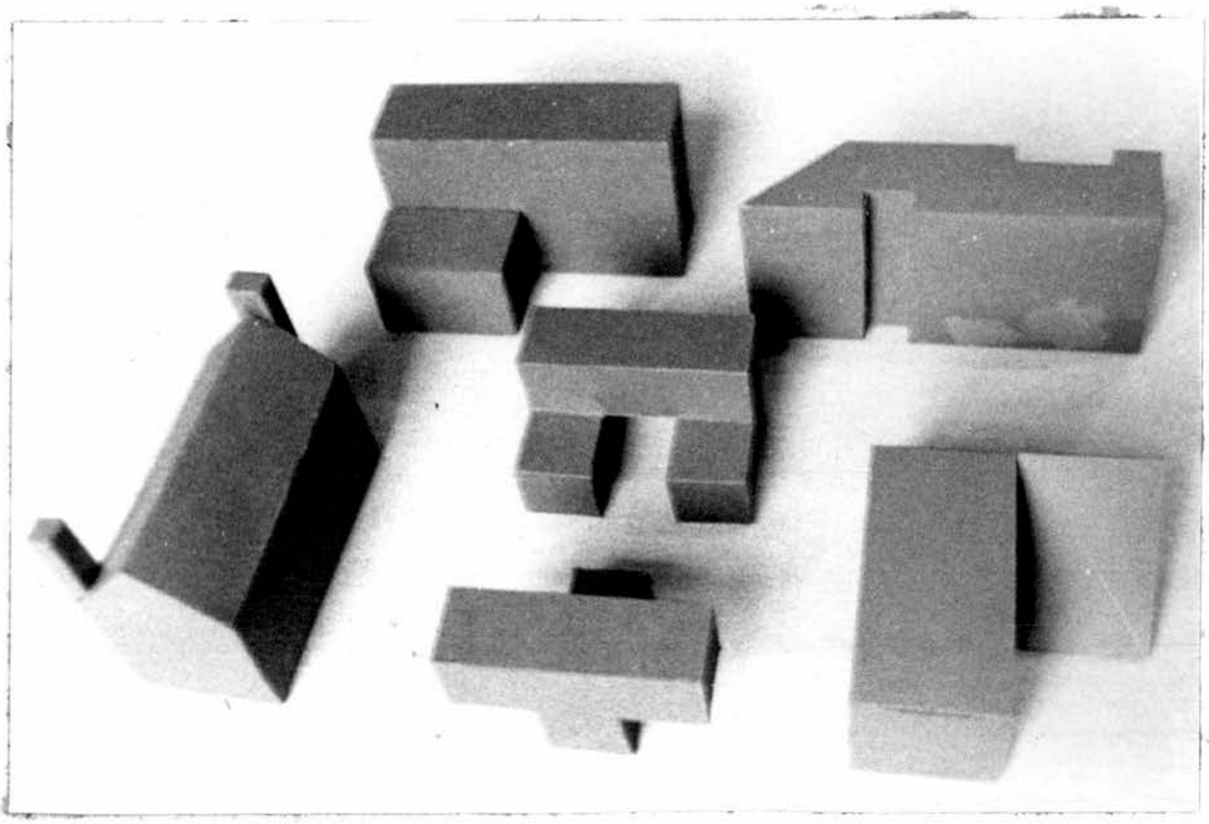


EXAMPLES OF WALKED RECORD FOR THE KEOGH TESTS

PHOTOGRAPH OF COACHING MODELS

PROJECT TWO

(page 579)



MODELS OF STIMULI OF MORAY HOUSE TEST
USED DURING COACHING